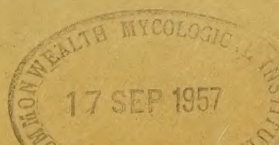


BIOLOGIA

CONTENTS

MUELLER, E. & AHMAD, S., Ueber einige neue oder bemerkenswerte Ascomyceten aus Pakistan II.	1
RAZA, S. M., The brain of <i>Uromastix hardwickii</i> Gray. Part I. External morphology	19
KHAN, SHAMS-UL-ISLAM, Culture of Algae of the Rice-fields of Kashmir	29
ASGHAR ALI, A list of the mosses of West Pakistan	44
NASIR, E., Two new species of <i>Bupleurum</i> from West Pakistan	53
NASIR, E., A key to the genera and the species of Umbelliferae of N. W. Himalaya and West Pakistan	56
HASHMI, T. A., The skeleton of <i>Rita rita</i> (Ham.)	73
ANSARI, M. ATIQR RAHMAN, <i>Bruelia elegans</i> sp. nov., a new louse parasitic on the Australian crow, <i>Gymnohorina tibicen</i> , with a supplementary note on the genus <i>Bruelia</i> Keler (Mallophaga : Ischnocera)	122

Published by
 THE BIOLOGICAL SOCIETY OF PAKISTAN
 Biological Laboratories, Government College,
 LAHORE



Biologia is published twice a year by The Biological Society of Pakistan, Lahore. The journal is available in exchange for publications of a similar character.

EDITORIAL BOARD

SULTAN AHMAD, Ph.D., D.Sc.

(Editor-in-Chief)

MUZAFFER AHMAD, Ph.D. . . . AHSANUL ISLAM, Ph.D.

SHAMS-UL-ISLAM KHAN, Ph.D.

All communications relating to the supply of the journal should be addressed to the Secretary, Biological Society of Pakistan, Biological Laboratories, Government College, Lahore.

BIOLOGIA

Vol. 3

JUNE 1957

No. 1

Ueber einige neue oder bemerkenswerte Ascomyceten aus Pakistan II.

Emil Müller und Sultan Ahmad

Institut für spezielle Botanik der Eidg. Techn. Hochschule, Zürich ;
Department of Botany, Government College, Lahore.

Als Fortsetzung früherer Arbeiten (Müller und Ahmad, 1955 ; Müller und Corbaz, 1955) möchten wir nachfolgend wiederum über einige neue oder sonst bemerkenswerte Ascomyceten berichten, welche im Gebiet von Westpakistan gefunden worden sind. Es ist uns daran gelegen, die Beschreibungen mit Abbildungen zu ergänzen, um das spätere Auffinden und Erkennen der Pilze zu erleichtern.

9. *Pleospora cephalandrae* nov. spec.

Perithecia fusca, subepidermalia, globosa vel saepe depressa, 400-600 μ diam. Ostiolo non in media parte apicis, cylindraceum vel cono simile, canale cum hyphis periphysibus similibus. Paries perithecorum 25-30 μ crassus, numerosis stratis cellularum, compressarum, 4-9 μ diam. compositus. Asci cylindracei vel clavati, longe pedunculati, bitunicati, 110-130 x 11-14 μ (p. sp. 75-85 μ), 8-spori. Sporae clavatae, base elongatae, transverse 5-septatae atque in partibus mediis longitudinaliter septatae, subhyalinae vel subfuscae, 18-25 x 7-8 μ . Paraphysoides hyalines fibrosae.

Hab. in caulibus emortuis *Cephalandrae indicae* Naud., Westpakistan, Changa Manga, 24. 3. 1954, leg. S. Ahmad (sub. Nr. 9042).

Die kugeligen oder meist etwas niedergedrückten, oft schüsselförmig eingesunkenen, 400-600 μ grossen, braunen Fruchtkörper wachsen zerstreut unter der Epidermis. Am Scheitel, meist deutlich excentrisch angeordnet, besitzen sie eine zylinderische oder kegelförmige Mündung, welche von

einem 40-70 μ weiten, innen deutlich mit periphysenartigen, verschleimenden und deshalb verklebten Hyphen besetzten Kanal durchbohrt sind. Die 25-30 μ dicke Perithecieinwand besteht aus zahlreichen Lagen von etwas zusammengepressten, oft kubischen, 4-9 μ langen, ziemlich zartwandigen, gegen innen fast hyalinen, aussen braunen Zellen.

Die zylindrisch-keuligen, lang gestielten, am Scheitel breit abgerundeten, derb- und doppelwandigen, 110-130 x 11-14 μ grossen (im sporenführenden Teil 75-85 μ langen), 8-sporigen Asci sind von zahlreichen fädigen, hyalinen Paraphysoiden umgeben. Die Ascosporen sind deutlich keulig, unten oft ziemlich lang geschwänzt, subhyalin bis gelb-bräunlich, 18-25 x 7-8 μ gross und durch 6, seltener 4-7 Querwände unterteilt. An der 2. oder 3. Querwand sind sie stärker, an den übrigen schwächer eingeschnürt und in den mittleren Partien überdies durch Längswände unterteilt.

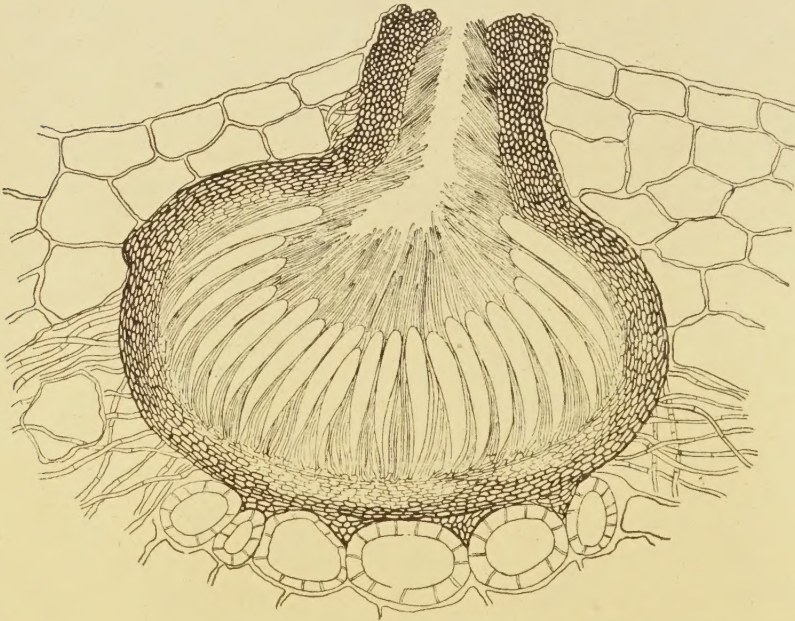


Abbildung 1. Schnitt durch einen Fruchtkörper von *Pleospora cephalandrae*.
Vergr. 250 x.

Pleospora cephalandrae ist ein typischer Vertreter der von Müller (1951) als Sektion betrachteten, von Munk (1953) als eigene Gattung aufgefassen Formenkreis *Cilioplea*. Dazu gehören sowohl die Sporenform (mehr schlank und spindelförmig-keulig), die Art der Septierung (nur

wenige Längssepten) und die Fruchtkörperform mit einem innen mit periphysenähnlichen Hyphen besetzten Ostiolum. Der Pilz besitzt eine charakteristische Sporenform, durch die er sich leicht von den übrigen Vertretern seines Verwandtschaftskreises unterscheiden lässt.

10. **Catharina cynodontis** nov. spec.

Perithecia depressa, rare globosa vel hemisphaerioforme, subcuticularia, 130-180 μ latitudinis, 90-130 μ altitudinis, Ostiolum papilliforme, poro setis opace fusci, brevibus perforatum. Parietis perithecorum 15-20 μ , stratis numerosis cellularum. Asci late cylindracei vel ellipsoidei, breviter pedunculati, bitunicati, 70-80 x 18-20 μ , transverse 5-septatae, constrictae, atque in partibus mediis longitudinaliter septatae.

Hab. in caulibus emortuis *Cynodontis dactylontis* L. = Westpakistan, Rawalpindi, 6. 8. 1954, leg. S. Ahmad.

Die niedergedrückten, seltener kugeligen oder halbkugeligen, 130-180 μ breiten und 90-130 μ hohen Fruchtkörper sitzen unter der Kutikula. Sie besitzen eine papillenförmig vorstehende, scheitelständige Mündung, welche von einem rundlichen Porus durchbohrt ist, in den hinein, kurze, opak schwarzbraune, stumpfe Borsten ragen und zuoberst die Mündung kranzartig umgeben. Die Perithechienwand ist seitlich und oben 15-20 μ dick und besteht aus mehreren Lagen von ziemlich abgeflachten, aussen fast schwarzbraunen, innen dünnwandigen und subhyalinen bis bräunlichen, 4-7 μ grossen Zellen. An der breit aufgewachsenen Basis ist sie nur 6-8 μ dick und besteht aus ein bis zwei Lagen von polyedrischen, ziemlich dünnwandigen und nur schwach gebräunten Zellen.

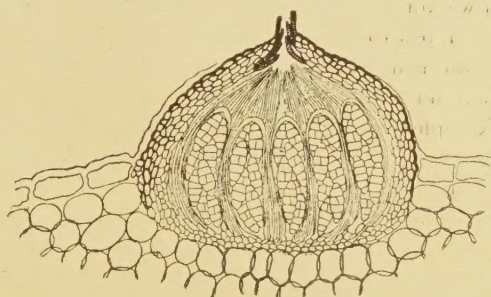


Abbildung 2. Schnitt durch einen Fruchtkörper von *Catharina cynodontis*. Vergr. 250 x.

Die nicht sehr zahlreichen Asci sind breit zylinderisch oder fast ellipsoidisch, unten kurz gestielt, am Scheitel breit abgerundet, derb- und

doppelwandig, 70-80 x 18-20 μ gross, 8-sporig. Sie sind von ziemlich breit fädigen Paraphysoiden umgeben. Die zweireihig im Ascus sitzenden Sporen sind breit spindelförmig, an den Enden meist etwas abgerundet, hyalin, 19-25 x 7,5-8,5 μ , mit 5 Querwänden versehen und an diesen etwas eingeschnürt. In einer oder beiden mittleren Partien sind sie überdies noch durch eine Längswand unterteilt.

Catharina cynodontis steht *Catharina straminis* (Harkn.) Berl. sehr nahe, unterscheidet sich aber in den kleinern Fruchtkörpern und Sporen, sowie in der Sporenseptierung. Beiden Arten ist aber das von einem Borstenkranz umgebene Ostiolum gemeinsam.

11. *Cucurbitaria indigoferae* nov. spec.

Perithecia globosa, 250-350 μ diam. solitaria vel complures, con crescent-es coniuncta, caespes formantes, sub cortice nascentia. Hypostroma nonnunquam minuta vel plerumque manifesta. Ostiola papilliformia, prima clausa demum irregulariter aperta. Paries perithecorum 30-50 μ , cellulis 6-10 μ diam. crassa tunicatis. Asci cylindracei, 80-90 x 10-12 μ , bitunicati, 8-spori. Sporae fusiformes vel clavatae, 18-27 x 5,5-8 μ subhyalines vel subfuscae, transverse 3-7-septatae atque in partibus compluribus longitudinaliter septatae. Paraphysoides hyalines fibrosae.

Hab. in ramis *Indigoferae Gerardianae* Wall. - Westpakistan, Shogran, 28.7.1956, leg. S. Ahmad.

Der Pilz besitzt einzelne oder gruppenweise miteinander verwachsene, aber meist mit flacher Basis dem Substrat aufsitzende, 250-350 μ grosse Fruchtkörper. Diese entstehen unter der Rinde, welche im Laufe der Fruchtkörperentwicklung rissig aufbricht und die Fruchtkörperbasen entblösst. Das Hypostroma ist zuweilen reduziert und nur als flache Kruste rings um die Fruchtkörperbasen ausgebildet, manchmal aber auch stärker entwickelt und dann ziemlich tief mit unregelmässig verteilten stromatischen Komplexen in das Substrat eindringend. Es setzt sich zusammen aus polyedrischen, nicht sehr derbwandigen, braunen, 3-5 μ grossen Zellen. Die Fruchtkörpermündungen stehen etwas konisch vor, sind anfänglich völlig geschlossen und öffnen sich später mit einem rundlichen Porus. Die Fruchtkörperwand ist 30-50 μ dick; aussen besteht sie aus sehr derbwandigen, zu äusserst schollig abbröckelnden, dunkelbraunen, 6-10 μ grossen, polyedrischen Zellen; gegen innen gehen diese allmählich in etwas grössere, 8-12 μ Durchmesser aufweisende, dünnwandigere, subhyaline bis leicht bräunliche und meist schwach zusammengepresste Zellen über.

Die zahlreichen zylinderischen, 80-90 x 10-12 μ grossen, derb- und

doppelwandigen Asci besitzen einen kurzen, aber deutlichen Stiel und sind von zahlreichen, fädigen Paraphysoiden umgeben. Sie enthalten je acht ein-, oder meistens zweireihig angeordnete, spindelig-keulige, 18-27 x 5, 5-8 μ grosse, subhyaline bis leicht bräunliche Sporen, welche 3-7 Querwände und in mehreren Partien überdies noch Längswände besitzen.

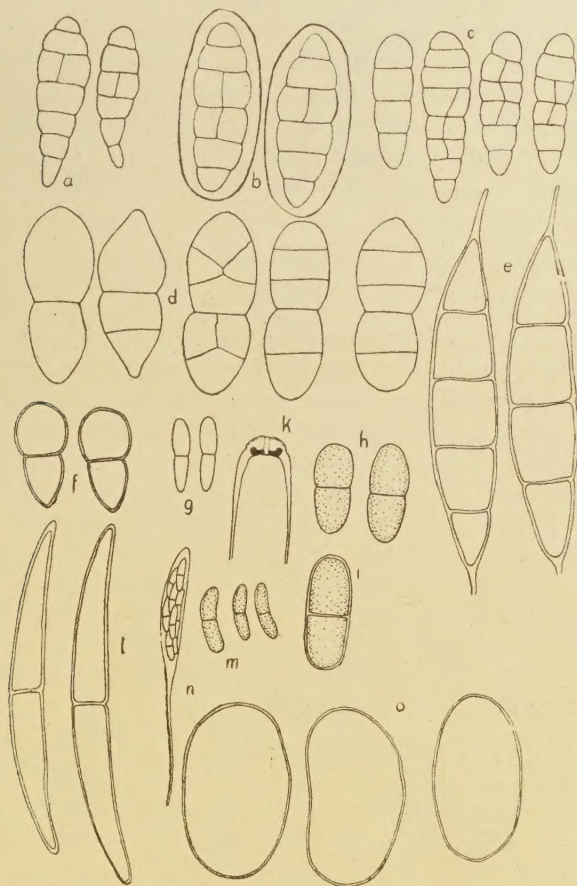


Abbildung 3. Sporenformen von a) *Pleospora cephalandrae*, b) *Catharina cynodontis*, c) *Cucurbitaria indigoferae*, d) *Peltosphaeria acaciae*, (Ascosporen), e) *Peltosphaeria acaciae* (Konidien), f) *Otthiella clavata*, g) *Mycosphaerella skimmiae*, h) *Amphisphaeria pakistani*, i) *Amphisphaeria millepunctata*, k) Ascusspitze von *Amphisphaeria pakistani*, l) Sporenform von *Lejosphaerella phoenicis*, m) Sporenform von *Haplovalsaria allantosporiformae*, n) Ascus von *Haplovalsaria allantosporiformae*, o) Sporenform von *Neophaacidium quercus*. (Vergr. a-m 1000 x, n 500 x, o 1000 x).

Cucurbitaria indigoferae weicht durch die schmalen Ascosporen von

den meisten übrigen Arten der Gattung ab, zeigt aber im sonst einen mit andern *Cucurbitaria*-arten sehr weitgehend übereinstimmenden Bau.

12. *Peltosphaeria acaciae* nov. spec.

Perithecia subepidermalia, globosa vel irregulariter tuberosa nonnunquam ellipsoidea vel lenticulata, 200-300 μ diam., solitaria vel compluria coniuncta. Ostiolum plerumque angustum, nonnunquam late apertum. Paries peritheciolorum apice crassior, base tenuiter tunicatus, cellulis 5 μ diam. bruneis. Asci late clavati vel ellipsoidei, bitunicati, 60-80 x 20-25 μ , non numerosi, paraphysoidibus fibrosis, hyalinibus subfuscis circumdati. Sporae clavatae, 18-26 x 8-10 μ , primum hyalinae, media parte septatae et contractae, deinde compluribus partibus transverse et longitudinaliter septatae.

Hab. in ramis *Acaciae modestae* Wall. - Westpakistan, Rawalpindi, 6.8.1954, leg. S. Ahmad (sub. Nr. 11070).

Die sich unter der Epidermis entwickelnden, kugeligen oder unregelmässig knolligen, oft aber auch liegend ellipsoidischen oder linsenförmigen, 200-300 μ grossen Fruchtkörper stehen einzeln oder zu wenigen miteinander verwachsen. Oben sind sie von einer sehr verdickten, bis 60 μ Mächtigkeit erreichenden Wand bedeckt, welche aber am Scheitel einen rundlichen, oft engen, zuweilen aber auch ziemlich weiten Mündungsporus frei lässt. Sie besteht aus kleinen nicht mehr als 5 μ grossen, derbwandigen, braunen, unregelmässig ineinander greifenden Zellen; nur gegen den Scheitel und zu äusserst sind diese etwas grösser. An der Basis ist die Gehäusewand oft sehr dünn und besteht aus wenigen Lagen von etwas zusammengepressten, nicht sehr derbwandigen, bräunlichen Zellen. Oft sind noch stromatische Komplexe vorhanden, die sich klypeusartig vom Scheitel her subkutikulär durch die Rinde ziehen, oft fehlen solche gänzlich.

Die Asci sind breit keulig oder ellipsoidisch, derb- und doppelwandig, 60-80 x 20-25 μ gross, nicht sehr zahlreich und nur an der Basis aufsitzend. Sie sind von zahlreichen, fädigen, bis 2 μ dicken, im oberen Teil oft etwas bräunlichen Paraphysoiden umgeben und enthalten je acht Ascosporen. Diese sind keulig, 18-26 x 8-10 μ gross, zunächst in oder schwach über der Mitte septiert und deutlich eingeschnürt. Später teilen sie sich oft noch unregelmässig mit Längs- und Querwänden, wobei sie bei der mittleren Einschnürung zuweilen auseinanderfallen. Im Alter, meist erst ausserhalb der Asci, erhalten sie noch einen ganz schwach bräunlichen Ton.

Dieser Pilz ist ausserordentlich schwierig zu interpretieren. Fast jeder Fruchtkörper sieht anders aus und auch die Sporenform ist sehr

variabel. Am besten passt er in die Gattung *Peltosphaeria* Berl.; er stellt aber einen relativ primitiven Typ dar, der—besonders im Verhalten der Sporen—am ehesten mit *Wettsteinina* v. Höhn. verglichen werden kann. Er weicht aber durch die deutlich fädig ausgebildeten Paraphysoiden von *Wettsteinina* ab.

Mit der Ascusform gemischt, kommt in sehr ähnlich gebauten Gehäusen ein Imperfekt vor, welcher sehr wahrscheinlich die Nebenfruchtkörper unseres Pilzes ist und am besten in die Formgattung *Stagonospora* Sacc. passt, sich aber durch länglich spindelförmige, hyaline, mehrfach querseptierte, oben in eine Spitze ausgezogene Konidien auszeichnet. Die Form lässt sich folgendermassen beschreiben:

Die unter der Epidermis entstehenden, 100-200 μ grossen, kugeligen oder ellipsoidischen Fruchtkörper besitzen oben eine sehr dicke, seitlich und an der Basis dünnere Wand. Diese besteht aus 3-6 μ grossen, derbwandigen, dunkelbraunen, unregelmässig ineinandergreifenden Zellen. Am Scheitel ist die Wand durch einen rundlichen Porus geöffnet, der aber lange durch zartwandige, bräunliche, ziemlich kleine Zellen verschlossen bleibt und sich erst spät ziemlich weit öffnet. Innen ist die Wand mit hyalinen, zelligen, höckerig vorstehenden Konidienträgern ausgekleidet, auf denen einzeln die länglich-spindelförmigen, hyalinen, derbwandigen, durch mehrere (4-7) Querwände unterteilte, am Ende oft in eine Spitze ausgezogene, 45-55 $\times$ 10-12 μ grosse Konidien abgeschnürt werden.

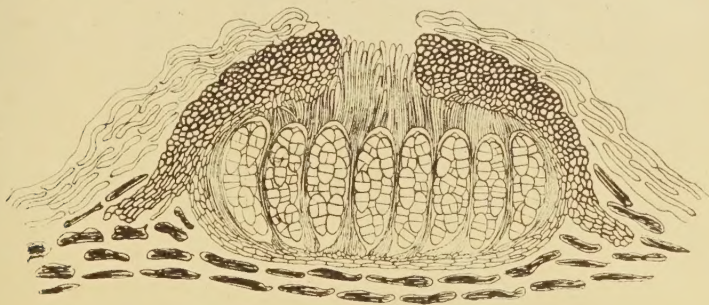


Abbildung 4. Schnitt durch einen Fruchtkörper von *Peltosphaeria acaciae*. Vergr. 250 x.

***Mycosphaerella skimmiae* nov. spec.**

Perithecia in gregas parvos disposita, globosa, 100-150 μ diam., epidermidem pustulatim, elevantia, erumpentia. Ostiolo plano papilliforme, poro pertuso. Pariete perithecorum 10-15 μ crasso e stratis 2-3

cellularum irregulariter vel rotundato-angulatarum plus minusve compressarum composito. Asci numerosi, cylindracei, fasciculatim in tuberculo convexule prominente minute celluloso sessiles, bitunicati, $42-48 \times 5-7 \mu$, 8-spori. Sporae distichae, fere clavatae, $8-11 \times 3-4 \mu$ circa medium septatae et constrictae, hyalinae.

Hab. in foliis emortuis *Skimmiae laureolae* Hk. Westpakistan, Changla Gali, August 1954, leg. S. Ahmad (sub Nr. 12000).

Die in kleineren oder grösseren, zuweilen die ganze Blattfläche überziehenden Herden der pustelförmig aufgetriebenen Epidermis eingewachsenen Fruchtkörper sind kugelig oder senkrecht ellipsoidisch, $100-150 \mu$ gross und dunkelbraun. Am Scheitel brechen sie mit einer papillenförmigen Mündung hervor; diese ist anfangs geschlossen, öffnet sich aber später mit einem ziemlich weiten, unregelmässig rundlichen Porus. Rings um die Mündung schliesst sich oft eine ringförmige Partie der sich über das Substrat erhebenden Fruchtkörperwand und bildet

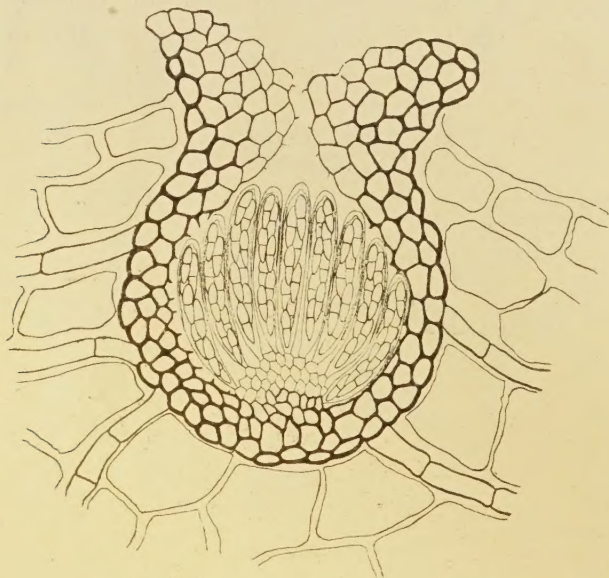


Abbildung 5. Schnitt durch einen Fruchtkörper von *Mycosphaerella skimmiae*. Vergr. 500 x.

zusammen mit der Mündung einen eigenartigen Trichter. Die Fruchtkörperwand ist $10-15 \mu$ dick und besteht aus wenigen Lagen von unregelmässigen oder rundlich-eckigen, $8-12 \mu$ grossen, aussen sehr derbwandigen und dunkelbraunen, innen dünnwandigeren und helleren Zellen. Die

dicht büschelig beieinanderstehenden Asci entspringen auf einem deutlich vorgewölbten, aus kleinen, rundlichen, zartwandigen, hyalinen Zellen bestehenden Basalpolster. Sie sind zylindrisch, bitunicat, $42-48 \times 5-7 \mu$ gross, und enthalten je acht zweireihig liegende, spindelig-keulige, $8-11 \times 3-4 \mu$ grosse, hyaline, in der Mitte septierte und etwas eingeschnürte Sporen. Paraphysoiden fehlen im reifen Fruchtkörper.

Mycosphaerella skimmiae zeichnet sich vor allem durch die sich ausserhalb des Substrates trichterförmig erweiternde Mündung aus. Eine ähnliche Erscheinung beschreibt Petrak (1950b) bei *Mycosphaerella sublibera* Petr., welche auf lebenden Blättern von *Pilea Melastomoides* Wedd [= *P. trinerva* Wight] in Ecuador wächst. Auch *Phragmosperma marattiae* (P. Henn.) Theiss. et Syd. besitzt eine derartige Mündung. *Phragmosperma marattiae* wurde schon früher (Müller, 1955) in die Nähe von *Sphaerulina* Sacc. und damit von *Mycosphaerella* Joh. gestellt; diese Auffassung, welche sich damals vor allem auf die Ausbildung der Fruchtschicht stützte, wird nun auch noch auf Grund dieser Aehnlichkeit in der Ausgestaltung der Mündung vertretbar. Die Gattung *Phragmosperma* Theiss. et Syd. wird kaum von *Sphaerulina* Sacc. zu trennen sein.

14. *Othiella clavatae* nov. spec.

Perithecia globosa vel irregulariter tuberosa, 200-250 μ diam. solitaria vel gibbera et hypostromati plano, crustaceo insidentia, sine ostiolum praeformatum, in maturitate irregulariter erumpentia. Paries perithecii 35-45 μ crassitudinis, crustaceus, in partibus exterioribus cellulis atro-

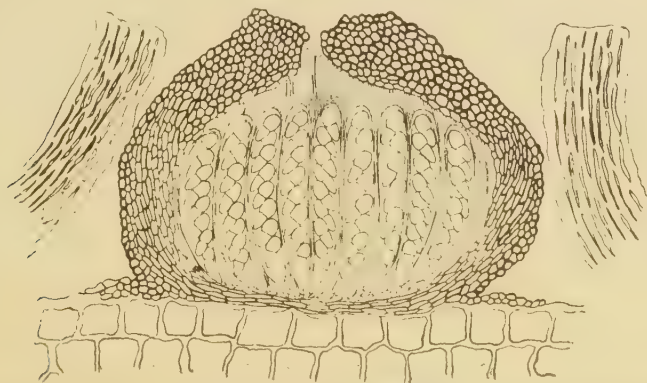


Abbildung 6. Schnitt durch einen Fruchtkörper von *Othiella clavata*. Vergr. 250 $\times$.

brunneis, 10-15 μ diam. leviter compressis, crasse tunicatis, in partibus inferioribus cellulis clarioribus, tenuiter tunicatis compositus. Asci numero-

sissimi, cylindracei, bitunicati, stipitati, 8-spore, 100-120 x 13-15 μ . Sporae hyalinae, 15-19 x 6-8 μ , epispore distincto involutae, clavatae, medio septatae et constrictae. Cellula superior plus minusve globosa, cellula inferior attenuata.

Hab. in ramis emortuis *Spiraeae Lindleyanae* Wall.-Westpakistan, Swat : Kulali, 18.8.1952, leg. S. Ahmad (sub. Nr. 9029).

Die einzeln oder in dichten Haufen rasenförmig beisammenstehenden, kugeligen oder unregelmässig knolligen, 200-250 μ grossen, oft mit flacher Basis aufgewachsenen und einem mehr oder weniger deutlich entwickelten, krustenförmigen, aus ziemlich derbwandigen Zellen bestehenden Basalstroma aufgewachsenen Fruchtkörper werden unter der Rinde angelegt, brechen aber im Laufe ihrer Entwicklung nach aussen durch und sind zuletzt fast oberflächlich. Sie besitzen keine vorgebildete Mündung; bei der Reife brechen sie am Scheitel unregelmässig auf. Die 35-45 μ dicke Gehäusewand ist derb-krustig. Aussen splittern kleinere oder grössere Partien schollig ab oder sind mit Rindenresten verwachsen. Die eigentliche Wand besteht im äussern Teil aus sehr derbwandigen, fast opak-schwarzen, 10-15 μ grossen, schwach zusammengepressten Zellen, im innern Teil werden diese allmählich heller, dünnwandiger und zuinnerst sind sie subhyalin oder nur schwach bräunlich. Häufig sind sie in von der zentralen Basis aus divergierenden Reihen angeordnet.

Die sehr zahlreichen, zylinderischen, 100-120 x 13-15 μ grossen, derb- und doppelwandigen, von zahlreichen fädigen Paraphysoiden umgebenen, unten in einen deutlichen Stiel zusammengezogenen Asci enthalten je acht Sporen. Diese sind keulig, in der Mitte septiert und eingeschnürt, im obern Teil fast kugelig sich im untern Teil keilförmig verjüngend, hyalin, 15-19 x 6-8 μ gross und von einem deutlichen Episor umgeben.

In der Gattung *Othtiella* Sacc. sind *Othtia*-formen mit hyalin bleibenden Ascosporen zusammengefasst. Es ist noch nicht klar, wie weit diese Gattung neben den *Othtia*-arten mit sehr hell gefärbten Sporen (vgl. z.B. Petrak, 1953 unter *Xenotthia* Petr.) bestehen bleiben kann.

15. *Amphisphaeria pakistanae* nov. spec.

Pseudostromata subepidermalia, subfusca, gelatinosa, hyphibus numerosis et cellulis substrati composita. Perithecia stroma immersa, depressa, 300-400 μ latitudinis et 250-300 μ altitudinis, subfusca. Ostiolum planum vel depresso cylindraceum, poro periphysibus fibrosis

perforatum. Paries perithecorum 20-30 μ crassitudinis duobus stratis. Stratus exterior cellulis irregulariter polyedricis, 8-12 μ diam. fuscis, interior subhyalinus, cellulis hyalinibus, 10-14 μ longitudinis compressis. Asci cylindracei, 80-100 x 8-9 μ base pedunculati, unitunicati, 8-spori. Paraphyses numerosae, hyalinae. Sporae bicellulatae, ellipsoideae, 14-16 x 5-6 μ , fuscae.

Hab. in caulibus emortuis *Indigoferae* spec. Westpakistan, Kalam, 19. 8. 1952, leg. S. Ahmad.

Der auf dünnen Zweigen der Wirtspflanzen wachsende Pilz bildet in der oft hypertrophisch aufgetriebenen Epidermis ausgedehnte Stromata. Das Wirtsgewebe wird teilweise aufgelöst und von einem aus zahlreichen, hellbraunen, zelligen, vielfach verflochtenen Hyphen bestehenden, fleischigen Stroma durchwuchert. Die Perithezien sind niedergedrückt kugelig, meist trocken schüsselförmig eingesunken, 300-400 μ hoch und dunkel gefärbt. Sie besitzen ein flache oder nur sehr schwach zylinderisch vorragende und dann oben abgestutzte, von einem ziemlich engen, mit zahlreichen, fädigen Periphysen besetzten Kanal durchbohrte Mündung. Die Gehäusewand ist 20-30 μ dick und deutlich zweischichtig. Aussen besteht sie aus sehr unregelmässig ineinandergreifenden, dunklen, 8-12 μ grossen, nicht sehr derbwandigen Zellen, welche nach aussen oft etwas höckerig vorstehen und von denen aus die Hyphen des Stromageflechtes in die umliegenden Wirtspartien eindringen. Innen ist die Gehäusewand hell-fleischig und besteht aus mehreren Lagen von subhyalinen bis hyalinen, oft mit zahlreichen Oeltröpfchen besetzten, stark zusammengepressten, 10-14 μ langen, zartwandigen Zellen.

Die zylinderischen, 80-100 x 8-9 μ grossen, am Grunde in einen kurzen Stiel auslaufenden Asci sind von zahlreichen fädigen, oft ebenfalls mit Oeltröpfchen besetzten Paraphysen umgeben. Ihre Wand ist einfach und zart, nur an der Spitze etwas verdickt und mit einem komplizierten, durch Jod färbbaren Apikalaparat versehen. Sie enthalten je acht, schräg einreihig liegende, hellbraun gefärbte, ellipsoidische, in der Mitte septierte und eingeschnürte, 14-16 x 5-6 μ grosse Ascosporen.

Amphisphaeria Ces. et de Not. ist nach der Typusart, *Amphisphaeria umbrina* (Fr.) Ces. et de Not. beurteilt, eine sphaeriale Gattung (vgl. Petrak, 1923). *Amphisphaeria pakistanae* steht *Amphisphaeria millepunctata* (Fuck.) Petr. am nächsten (vgl. Petrak, 1923), unterscheidet sich aber von dieser Art durch das meist bedeutend stärker ausgebildete, fleischige Stroma, durch die deutlich zweischichtige Perithezienwand

und vor allem durch die an den Enden sich verjüngenden, in der Mitte deutlich eingeschnürten Ascosporen. Wir haben auch *Amphisphaeria millepunctata* in Pakistan feststellen können.

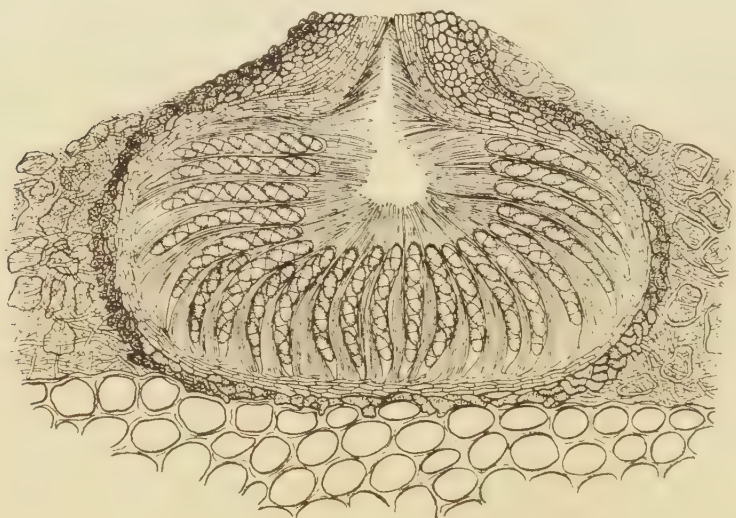


Abbildung 7. Schnitt durch einen Fruchtkörper von *Amphisphaeria pakistanae*. Vergr. 250 x.

Ausser auf *Indigofera* haben wir den Pilz noch auf *Plectranthus rugosus* Wall. gefunden.

16. *Haplovalsaria allantosporiforma* nov. spec.

Stromata tuberosa, 400-700 μ latitudinis et 300-500 μ altitudinis, solitaria vel in ordinibus composita, substrato immersa, crusta 20-40 μ crassitudinis fuscis hyphibus contextis circumdata, pars interior subalba hyphibus hyalinibus composita. Perithecia solitaria vel compluria, in stroma immersa, globosa vel ellipsoidea, saepe irregulariter compressa, 250-500 μ diam. Ostiolum solum e stroma erumpens, canale periphysato perforatum. Paries perithecorum 20-30 μ crassitudinis, stratis subfuscis cellularum compressarum compluribus 5-8 μ diam. compositus. Asci numerosi, clavati, longe pedunculati, pars spor. 35-45 $\times$ 7 μ , 8-spori, unitunicati, paraphysibus fibrosis circumdati. Sporae oblongae curvatae vel cylindratae, fuscae, media parte septatae, 9-11 $\times$ 2,5-3 μ .

Hab. in lignis dejectis-Westpakistan, Lun Bagla. 6.9.1955, leg. S. Ahmad, (sub Nr. 14005)

Die knolligen, im Umriss meist mehr oder weniger rundlichen,

400-700 μ im Durchmesser aufweisenden und 300-500 μ hohen Stromata sitzen einzeln oder zu mehreren dicht nebeneinander stehend und oft Längsreihen in der Faserrichtung bildend dem Substrat auf, sind aber an ihrer Basis fest im Holz verankert. Aussen besitzen sie eine 20-40 μ dicke Kruste aus braunen, sich gegenseitig durchflechtenden Hyphen, denen unregelmässig, oft aber dicht zerstreut, ziemlich derbwandige, im Umriss rundliche, 5-10 μ grosse, braune Zellen eingelagert sind. Innen ist die Stromasubstanz weisslich und besteht aus einem zwar meist lockeren aber starren Geflecht aus zartwandigen, ca 2-2,5 μ breiten, hyalinen Hyphen. An der Basis ist keine scharfe Grenze; die Hyphen des Stromagewebes dringen in die Holzzellen ein, durchweben auch die Zwischenzellräume und erfüllen hier und da grössere Hohlräume des Holzkörpers.

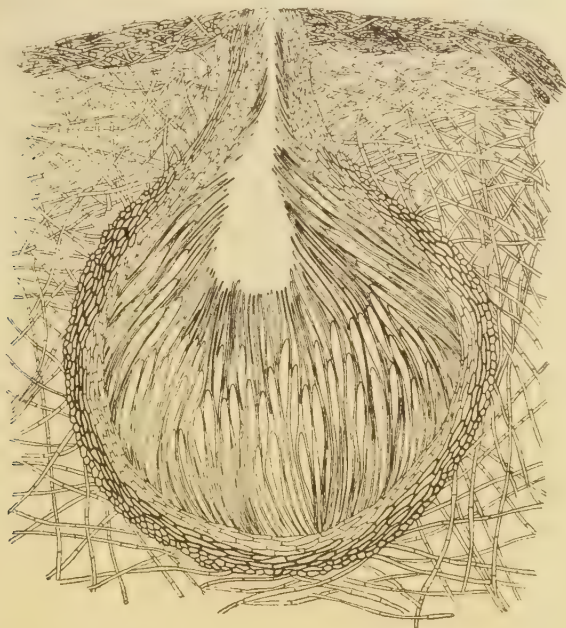


Abbildung 8. Schnitt durch eine Stromapartie mit einem Fruchtkörper von *Haplovalsaria allantosporiforma*. Vergr. 250 x.

Die Perithezien sind einzeln oder zu wenigen dem Stroma vollständig eingewachsen und brechen nur mit der meist kegelförmigen, zuweilen auch zylinderischen, von einem periphysierten Kanal durchbohrten Mündung hervor. Im Umriss sind sie rundlich oder senkrecht

ellipsoidisch, 250-500 μ gross, oft aber durch gegenseitigen Druck sehr unregelmässig. Die Gehäusewand ist 20-30 μ dick und besteht aus zahlreichen Lagen von aussen ziemlich stark, nach innen schwächer braun gefärbten, 5-8 μ grossen, deutlich zusammengepressten Zellen, die zuinnerst zartwandig und hyalin und fast faserig werden.

Die zahlreichen keuligen, deutlich aber oft sehr verschieden lang, gestielten, im sporenführenden Teil 35-45 x 7 μ messenden Asci sind zartwandig und am Scheitel mit einfacher Apikalplatte versehen. Der Stielteil misst 20-80 μ . Die Asci sind umgeben von fädigen, meist sehr langen, hyalinen Paraphysen. Die zu acht meist zweireihig im Ascus liegenden Sporen sind wurstförmig gekrümmt oder zylinderisch, in der Mitte septiert und nur sehr wenig eingeschnürt, braun und messen 9-11 x 2,5-3 μ .

Die Gattung *Haplovalsaria* wurde von v. Höhnelt (1910) auf *Haplovalsaria simplex* v. Höhn. begründet. Diese Art zeichnet sich aus durchein—nach der Beschreibung—weisses Stroma ringsum die Mündung, während das Stroma unseres Pilzes viel stärker entwickelt ist und auch oft mehr als ein Perithecium enthält. Aber in der Fruchtschicht besteht eine sehr gute Uebereinstimmung: die spindelig-keuligen, zartwandigen, sehr verschieden lang gestielten Asci, die langen Paraphysen und die zweizelligen, braunen Sporen.

17. *Lejosphaerella phoenicis* nov. spec.

Perithecia solitaria vel congregata et coniuncta, substrato immersa, depressa vel lenticulata, 250-350 μ latitudinis, 140-200 μ altitudinis, fusca, clypeo epidermali tecta. Ostiolum planum, canale periphysato perforatum. Paries peritheciorum base 8-12 μ crassitudinis, in lateribus crassior, cellulis plus minusve compressis. Asci numerosi, ellipsoidei, 65-90 x 16-19 μ , unitunicati, apice paulum crassiores, in mediam partem perithecii inclinati, 8-spori. Sporae fusiformes, saepe curvatae, media parte septatae et paulum constrictae hyalines, epispora distincta, 48-58 x 4,5-5,5 μ . Paraphyses hyalines, fibrosi.

Hab. in rachibus emortuis *Phoenicis dactyliferae* L. - Westpakistan, Lahore, 14. 3.1948, leg. S. Ahmad (sub Nr. 2267).

Die zerstreuten oder zu wenigen in Gruppen dicht zusammenstehenden und meist verwachsenen, dem Substrat vollständig eingesenkten, dieses aber häufig pustelförmig auftreibenden, niedergedrückt kugeligen oder linsenförmigen, 250-350 μ breiten, 140-200 μ hohen Fruchtkörper sind dunkelbraun. Sie sind von einem undeutlichen, oft nur spärlich vorhandenen, epidermalen Klypeus bedeckt, welcher die sklerenchymatischen Epidermiszellen mit einem dunklen, aus rundlichen braunen Zellen beste-

henden Gewebe erfüllt. Die nach aussen brechende Mündung besteht aus oft sehr zahlreichen Reihen von senkrecht parallelen, ziemlich flachen, 3-5 μ breiten und bis 20 μ langen, hellbraunen Zellen, welche sich zu oberst schwach aber doch ziemlich deutlich verbreitern. Sie ist von einem konischen Kanal durchbohrt, in den hinein zahlreiche, ziemlich breit fädige Periphysen ragen. Die Gehäusewand ist an der Basis nur 8-12 μ dick, seitlich und gegen den Scheitel wird sie allmählich dicker. Sie ist aus zusammengepressten, nicht sehr derbwandigen, bis 20 μ langen Zellen aufgebaut, welche gegen innen allmählich in einige Schichten von hyalinen, dünnwandigen, mit zahlreichen Oeltropfen erfüllten Zellen übergehen.

Die ziemlich zahlreichen, ellipsoidischen, 65-90 $\times$ 16-19 μ grossen, zartwandigen, am Scheitel mit verdickter Membran versehenen aber keinen Apikalaparat einschliessenden Asci neigen gegen die Mitte des Fruchtkörpers zusammen. Sie sind von zahlreichen, breit fädigen, viele Oeltropfen enthaltenden Paraphysen umgeben und enthalten je acht gebündelt liegende Ascosporen. Diese sind spindelförmig, meist deutlich gekrümmt, hyalin, von einem deutlichen Epispor umgeben, in der Mitte septiert, aber kaum eingeschnürt und messen 48-58 $\times$ 4,5-5,5 μ .

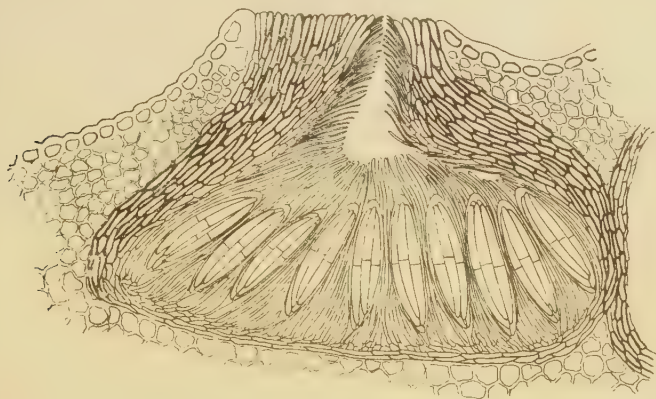


Abbildung 9. Schnitt durch einen Fruchtkörper von *Lejosphaerella phoenicis*. Vergr. 250 x

Auch die Gattung *Lejosphaerella* wurde von v. Höhnelt (1919) begründet. Typus ist *Lejosphaerella praeclara* (Rehm) v. Höhn. [= *Didymella praeclara* Rehm]. Auch diese Gattung ist sphaerial gebaut und passt am besten in die Familie der *Polystigmataceae*. Sie unterscheidet sich aber von andern Gattungen mit zweizelligen, hyalinen Sporen durch die stark niedergedrückten, von einem Klypeus bedeckten Perithezien, und durch die langen, mit einem deutlichen Epispor versehenen Ascosporen.

18. *Neophacidium quercus* nov. spec.

Apothecia in foliis viventibus subepidermalio epiphylla crescentia, orbicularia vel elliptica, 300-500 μ diam., solitaria vel compluria coniuncta, primum clausa demum rima longiuscula vel laciniis obtuse triangularibus disrumpente. Stratus base pseudoparenchymaticus, 8 μ crassitudinis, subfuscus. Stratus tegens 18-25 μ crassitudinis cellulis 5-8 μ diam., fuscis. Asci pauci ellipsoidei vel clavati, 70-90 x 25-30 μ , 4-8-spori, crasse tuni-
cati, breviter pedunculati. Sporae ellipsoideae, continuae, hyalines, 25-28 x 12-14 μ . Paraphyses numerosissimae, fibrosae, base hyalines, apice fuscae.

Hab. in foliis *Quercus* spec. - Westpakistan, Kagan valley, Sept. 1950, leg. S. Ahmad.

Die höckerigen, im Umriss rundlichen oder elliptischen, zuweilen sehr unregelmässigen, 300-500 μ Durchmesser und 120-140 μ Höhe aufweisenden Ascomata wachsen epiphyll unter der Kutikula, dringen aber oft-besonders am Rande - mit dunklen stromatischen Komplexen in tiefere Gewebepartien ein. Sie sind manchmal sehr spärlich, manchmal in dichten Herden auf den Wirtsblättern zu finden, zuweilen stehen sie so dicht, dass sie zu mehreren zusammenfliessen. Anfangs sind sie völlig geschlossen, später brechen sie an verschiedenen Stellen des Scheitels spaltenförmig auf oder werfen grössere Deckschichtpartien ab, sodass die Fruchtschicht mehr oder weniger discomycetenartig entblösst wird. Die Wand ist basal nur bis 8 μ dick und besteht aus wenigen Lagen von mehr oder weniger rechteckigen, ziemlich zartwandigen, hellbraunen, 3-5 μ grossen Zellen. Seitlich und am Scheitel sind die Wände 18-25 μ dick und bestehen aus grösseren, 5-8 μ messenden, unregelmässig rundlichen, derbwandigen Zellen, welche zu innerst in etwas zartwandigere, dornig nach innen ragende Zellen übergehen. Die unterste Partie der seitlichen Wand ist mit senkrecht parallelen Reihen von mehr oder weniger gestreckten, meist nicht sehr derbwandigen Zellen mit der Basis verbunden.

In der Fruchtschicht sitzen die Asci, oft durch ziemlich grosse Zwischenräume voneinander getrennt, parallel nebeneinander. Sie sind breit ellipsoidisch oder keulig, ziemlich dickwandig, aber deutlich unitunicat gebaut, 70-90 x 25-30 μ gross, unten mit einem kurzen, knopfigen Stiel in der Basalschicht sitzend und am Scheitel ziemlich deutlich verjüngt. Sie sind von zahlreichen, sie überragenden, zellig gegliederten Paraphysen umgeben, welche sich oft in der oberen Hälfte braun anfärben und sich durch ziemlich derbe Wände auszeichnen. Die 25-28 x 12-14 μ grossen, ellipsoidischen, oft etwas bohnenförmigen, hyalinen, von einem körnigen Plasma erfüllten und sich zuletzt ganz schwach bräunlich verfärbenden Ascosporen sitzen zu 4, 6 oder 8 in den Asci.

Wir hatten Gelegenheit, das Petrak (1950) zur Verfügung stehende, der Gattungsdiagnose von *Neophacidium* Petr. zu Grunde liegende Material

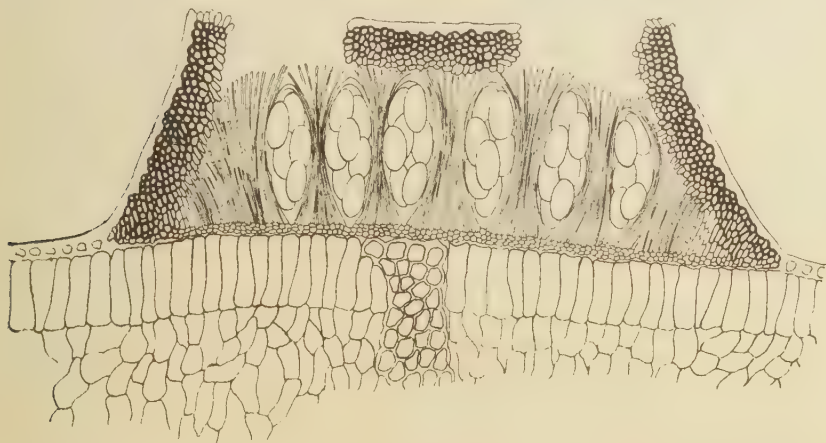


Abbildung 10. Schnitt durch einen Fruchtkörper von *Neophacidium quercus*. Vergr. 250 x.

von *Phacidium macrocarpum* Pat. zu untersuchen und mit unserem Pilz zu vergleichen. Es unterliegt keinem Zweifel, dass die beiden Formen gattungsgleich sind. Hingegen besitzt *Neophacidium macrocarpum* (Pat.) Petr. grössere Sporen, die seitlichen Wände der Ascomata sind bei *Neophacidium quercus* derber und diese Art hat auch im oberen Teil oft bräunliche Paraphysen.

Herr Dr. J. A. von Arx, Baarn (Holland) hat uns in freundlicher Weise des Material einiger der oben erwähnten Pilze ebenfalls untersucht, und wir konnten mit ihm über deren Gattungsangehörigkeit diskutieren. Da für danken wir ihm recht herzlich.

LITERATURE

- v. Arx J. A. und Müller, E. 1954—Die Gattungen der amerosporen Pyrenomyceten—Beitr. z. Krypt. fl. Schweiz, **11**, (1) 1-434.
- v. Höhnelt, F. 1919 a—Fragmente zur Mykologie Nr. 1168—Sitzber. Akad. Wiss. Wien. math.—naturw. Kl. **128**, 577-579.
- 1919 b—Fragmente zur Mykologie Nr. 1171-l. c. 582-584.
- Müller, E. 1951—Sydowia **5**, 248-310.
- 1955—l. c. **9**, 216-220.

———et Ahmad, S. 1955—l.c. 233-245.

———et Corbaz, R. 1955—l.c. 256-259.

Munk, A. 1953—Dansk Botanisk Arkiv, **15**, (2) 1-163.

Petrak, F. 1923—Mykologische Notizen Nr. 298-Ann. Myc. **21**, 326-331.

———1950 a—Sydowia **4**, 333.

———1950 b—l. c. 505-506.

———1953—l. c. **7**, 50-78.

The brain of *Uromastix hardwickii* Gray

Part I. External morphology.

S. MOHSIN RAZA, M.Sc.

Department of Zoology, Government College, Lyallpur.

INTRODUCTION

The lizard *Uromastix hardwickii* has long been studied in the various Universities of West Pakistan as a type of the Class Reptilia, but surprisingly enough, an authentic account of some of its systems, including the nervous system, is not yet available. The present paper deals with the gross morphology of its brain; the histological structure of this organ will be described in a subsequent paper. Wherever possible, I have compared the brain of *Uromastix* with that of *Sphenodon*, *Lacerta*, *Chelone*, *Testudo* and other reptiles.

The external morphology of the brain was, for the most part, studied directly by means of a binocular microscope, but the studies on the various contours, cavities and recesses were supplemented with microtomy. The sulci of the cerebral hemispheres were best studied in brains dipped in eosine solution and examined with artificial light thrown from different angles in succession. In addition to the various camera lucida drawings, a semi-diagrammatic vertical section was drawn with the help of serial and hand-cut median sections of the complete brain to show the relations of the different parts.

GENERAL FEATURES

When viewed from lateral side, the brain of *Uromastix hardwickii* appears roughly Z-shaped. It is covered by a loose, highly vascular transparent membrane which represents the arachnoid tissue and lies between pia mater and dura mater. The large venous sinuses of the endocranial vascular system are closely related to the dura mater which is a strong, thick, tough, pigmented membrane adhering firmly to all the bones of the roof of the cranium except the parietal and the supraoccipital. The spaces between the various parts of the brain are occupied by the pia-arachnoid membrane with a number of blood vessels in it. These relations

of the pia-arachnoid membrane have been described by Goldby (1934) between the cerebellum and optic lobes in *Lacerta viridis*.

The cerebral hemispheres (Fig. 1, *C. H.*) are the largest part of the brain. They lie parallel to one another and do not diverge posteriorly as in *Chelone midus* (de Lange, 1911). They abut completely against the anterior surface of the optic tectum, thus enclosing a small space in which the dorsal sac along with the invaginated folds of arachnoid membrane may be seen. The optic lobes are large and rounded and are not flattened antero-posteriorly as in *Chelone*. The cerebellum is a vertical plate, hanging over the anterior part of the fourth ventricle, as in *Testudo geometrica* (Schepers, 1938). In *Testudo geometrica*, the whole of the fourth ventricle is left exposed to view in dorsal aspect due to the thinness of the cerebellum, but in *Uromastix hardwickii* it is out of view, being hidden by the medulla oblongata which makes almost a right angle with the spinal cord (Fig. 1).

CEREBRAL HEMISPHERES

The telencephalon of *Uromastix hardwickii* does not differ greatly from that of *Lacerta viridis* and *Sphenodon*. It is of macromastic type, with well-developed olfactory bulbs joined to the hemispheres by peduncles of moderate size. The brain of *Uromastix* differs from that of *Lacerta viridis* and other lizards, and resembles that of *Sphenodon* (Cairney, 1926) in the absence of accessory olfactory bulbs.

The olfactory bulbs are pedunculated, long, and roughly triangular in shape (Fig. 1, *Olf. B.*) and resemble those of *Lacerta viridis*. The base of the triangular olfactory bulb is directed anteriorly, while the apex is continuous posteriorly with the olfactory peduncle. The inner sides of these bulbs are closely applied to each other throughout their whole length. From the antero-lateral margin of the base of olfactory bulb arises a short nerve which supplies the dorsal part of the snout. The olfactory nerve arises from the antero-ventral aspect of the base of the olfactory bulb (Fig. 1, *Olf. N.*). It goes vertically downwards parallel to the nasal septum and supplies the ventral portion of the nasal capsule. The sulcus lobaris and the lateral groove, described by Schepers (1938) in *Testudo geometrica*, are not represented here at all. In this respect the olfactory bulbs resemble those of *Lacerta viridis*. The olfactory peduncles are moderate in size and occupy the canalis olfactorius above the interorbital septum and below the frontals (Islam, 1955). The olfactory peduncle passes insensibly on one hand into the olfactory bulb and on the other into the olfactory lobe of the hemisphere. The cavity of the bulb, i. e.,

The brain of *Uromastix hardwickii* Gray

Part I. External morphology.

S. MOHSIN RAZA, M.Sc.

Department of Zoology, Government College, Lyallpur.

INTRODUCTION

The lizard *Uromastix hardwickii* has long been studied in the various Universities of West Pakistan as a type of the Class Reptilia, but surprisingly enough, an authentic account of some of its systems, including the nervous system, is not yet available. The present paper deals with the gross morphology of its brain; the histological structure of this organ will be described in a subsequent paper. Wherever possible, I have compared the brain of *Uromastix* with that of *Sphenodon*, *Lacerta*, *Chelone*, *Testudo* and other reptiles.

The external morphology of the brain was, for the most part, studied directly by means of a binocular microscope, but the studies on the various contours, cavities and recesses were supplemented with microtomy. The sulci of the cerebral hemispheres were best studied in brains dipped in eosine solution and examined with artificial light thrown from different angles in succession. In addition to the various camera lucida drawings, a semi-diagrammatic vertical section was drawn with the help of serial and hand-cut median sections of the complete brain to show the relations of the different parts.

GENERAL FEATURES

When viewed from lateral side, the brain of *Uromastix hardwickii* appears roughly Z-shaped. It is covered by a loose, highly vascular transparent membrane which represents the arachnoid tissue and lies between pia mater and dura mater. The large venous sinuses of the endocranial vascular system are closely related to the dura mater which is a strong, thick, tough, pigmented membrane adhering firmly to all the bones of the roof of the cranium except the parietal and the supraoccipital. The spaces between the various parts of the brain are occupied by the pia-arachnoid membrane with a number of blood vessels in it. These relations

generally the condition in the reptiles. The posterior part of the fissure, in view of its relationship with the internal cell formation, is evidently homologous with the posterior half of the endorhinal sulcus in *Lacerta viridis* (Goldby, 1934), but it is devoid of separate horizontal and vertical limbs. It also corresponds with amygdaloid fissure in *Cistudo carolina* (Johnston, 1915) and is comparable to the lower, horizontal, backwardly directed limb from the vertical branch of endorhinal sulcus in *Testudo geometrica* (Schepers, 1938). The remaining part of this sulcus fades out in the anterior region and may be called the horizontal limb of the endorhinal sulcus. On the dorsolateral margin of the hemisphere is a deep groove (Figs. 1&2, A.En.S.), which sweeps backward a little from the anterior region and may be called the anterior endopyriform sulcus because it corresponds to a sulcus of that name, described by Schepers (1938), not only in its situation but also in its relation to the pyriform cortex.

Medially, almost in the middle of the hemisphere, there is a groove (Figs. 2, F.L.H.) which runs along the ventral side of the hippocampal cortex. Anteriorly it moves upwards and becomes continuous with a small groove, fading out gradually in the posterior direction. Posteriorly this depression appears to follow the contour of the posterior pole. This sulcus is invariably present in reptiles and has been called fissura arcuata by Herrick (1910), fimbriodentate sulcus by Johnston (1915) and fissura septocartialis by de Lange (1911) and Kappers (1921). The topographical relations of this sulcus suggest strongly that it should be homologized with the fissura limitans hippocampi of *Sphenodon* (Smith, 1903). Just below the posterior end of the fissura limitans hippocampi, near the edge of the posterior pole of the hemisphere, there is a foramen, called the interventricular foramen (Fig. 2, I.F.), through which the lateral ventricle communicates with the third ventricle. A sulcus, which may be named the oblique sulcus (Ob.S.), starts from here and runs obliquely towards the anteroventral side. On covering one-third the distance, this sulcus bends ventrally and fades out

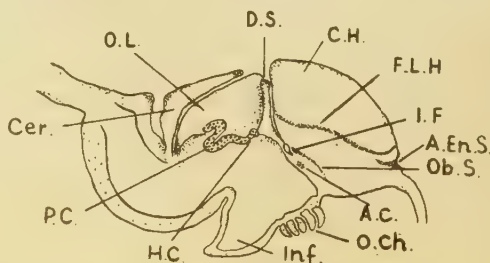


Fig. 2. THE BRAIN : Semi-diagrammatic longitudinal section. [x2].

A.C., anterior commissure; A.En.S., anterior endopyriform sulcus; Cer., cerebellum; C.H., cerebral hemisphere; D.S., dorsal sac; F.L.H., fissura limitans hippocampi; H.C., habenular commissure; I.F., interventricular foramen; Inf., infundibulum; Ob.S., oblique sulcus; O.Ch., optic chiasma; O.L., optic lobe; P.C., posterior commissure.

gradually. Such a sulcus has not been reported in *Lacerta viridis* and *Testudo geometrica*. The posterior portion of the medial surface of the hemispheres is more or less straight, but is obscured from view by the forward bulging of the optic tectum and diencephalon. The fissura limitans hippocampi may be traced further over this part of the medial surface. The longitudinal sulcus of Varanidae is absent on the dorsal surface. A deep groove at the anterior end makes it possible to distinguish the olfactory lobe from the cortical part of the cerebral hemisphere. This groove runs posteriorly close to the outer margin of the hemisphere and disappears gradually. From its position this groove appears to be homologous with the anterior endopyriform sulcus as described by Schepers (1938) in *Testudo geometrica*. Between the olfactory lobes of the hemispheres, there is a rhomboidal area, where this sulcus is continuous on the medial aspect. Goldby (1934) says that the fissura limitans medially and endorhinal fissure laterally appear to be the only fissures constant enough to be of comparative morphological value in the various orders of reptiles.

VENTROLATERAL REGION OF HEMISPHERES

This is a well-developed region and includes the corpus striatum and the amygdaloid complex. In Johnston's (1915) view the pyriform cortex, due to its relations to the amygdaloid complex and its position below the zona limitans lateralis, should also be included in this region. The medial surfaces of the hemispheres are flattened over the areas where they are applied against each other. No nerve corresponding to the nervus terminalis (Johnston, 1913) and no sulcus septocarnalis (Schepers, 1938) are present here. Only the olfactory nerve arises from the antero-ventral margin of the olfactory bulb. Owing to the complexity of this region and the difficulty in homologizing its different parts, a confusing nomenclature has grown up around it. This region cannot be delimited on the outer surface of the brain. Its most characteristic feature is its growth into the ventricular cavity.

LATERAL VENTRICLE

The ventricle is less capacious than could be expected, and appears crescentic in shape in a transverse section. This condition can be compared easily with that in other reptiles, especially in Sauria, Serpentes and Loricata. The reduction of this cavity is due to the enormous ingrowth of the hemisphere wall below (i. e., at the level of) the endorhinal fissure. This conspicuous prominence hanging in the lateral ventricle has been given various names such as neostriatum (Kappers, 1921), hypopalial eminence (Smith, 1919), dorsoventricular ridge (Johnston, 1915), etc. It is a

complex structure and none of these names describes it fully and accurately. It is, therefore, more appropriate to designate it by the non-committal name of "Hunter's eminence" in honour of its discoverer, John Hunter. This name has been used also by Goldby (1934) in his description of the brain of *Lacerta viridis*. The greater part of this prominence is occupied by the hypopallium (Smith, 1919), the basal part by the paleostriatum and the remaining part by the amygdaloid complex. The Hunter's eminence commences at the anterior pole of the hemisphere as a slight convexity of the ventrolateral wall. It expands rapidly into the pendulous eminence which fills nearly the whole of the ventricular cavity and terminates abruptly in the posterior pole of the hemisphere. The lateral ventricle is continuous anteriorly with the cavity of the olfactory bulb through the cavity of the peduncle, and opens posteriorly into the third ventricle through the interventricular foramen.

COMMISSURES

At the base of the cerebral hemispheres in the lamina terminalis lies a mass of transverse nerve fibres, the anterior commissure (Figs. 2&3, A.C.). It is roughly oval in shape and corresponds with the anterior commissure of *Lacerta viridis*. There is no hippocampal commissure in *Uromastix hardwickii*.

Behind and at the base of the dorsal sac, in the roof of the diencephalon, there are two habeneular ganglia connected by the habeneular commissure (Fig. 2, H. C.).

Next to the habeneular commissure, below the optic tectum, there is a clear posterior commissure (Fig. 2, P. C.) in the form of a thick band. This band of nerve fibres is a constant feature of reptiles.

DIENCEPHALON AND EPENDYMAL RECESSES

The diencephalon is obscured from view due to the evagination of the dorsal sac from its surface. The infundibulum and its recesses are the outgrowths of its floor. The lateral walls bulge in the third ventricle and form the thalami. From the dorsal surface arise the epiphysial organs which are enclosed in the dorsal sac. The choroid plexus also hangs in it.

The third ventricle, which is exposed in a median section, has several ependymal recesses (Fig. 3, P. O. R. & Pr. O. R.) The one formed between the optic chiasma below and the lamina terminalis above is the preoptic recess and corresponds to the recess of that name described in *Testudo geometrica* (Schepers, 1938). It is limited behind and laterally by the hypothalamic eminence. There is not the slightest indication of any

recess which can be compared with the supracommissural recess of *Testudo*, and the supracommissural diverticulum of the third ventricle, described by Smith (1899) in *Ornithorhynchus*. Another recess—the post-optic recess—bounded by the optic chiasma above and the infundibulum below, can also be recognized. The lateral and posterior sides of this recess are limited by the hypothalamic eminence.

A third recess of the roof of the third ventricle is the dorsal sac (Fig. 2, D. S.). It appears as an oval body surrounded by the cerebral hemispheres antero-laterally and the optic tectum postero-laterally, thus covering the diencephalon dorsally. The upper surface of the dorsal sac is applied to the pigmented dura mater which is in contact with the bones in this region. When the cerebral hemispheres and the optic tectum of one side are removed, the dorsal sac comes in view as a curved tube arising from the roof of the third ventricle. It is lined by the ependyma and has an external covering of pia mater. It encloses the epiphysial organs and the choroid plexus of the third ventricle. The plexus hangs downwards to enter the lateral ventricle through the intervenricular foramen. The walls of the sac are very thin. The anterior wall of the sac merges imperceptibly with its lateral walls and the latter are attached below to the cerebral hemispheres and the diencephalon.

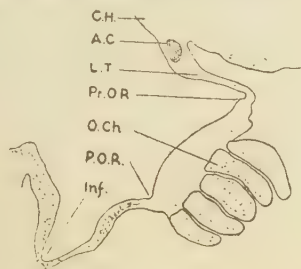


Fig. 3. THE BRAIN : Longitudinal section of a portion of the floor. [x 4.]

A.C., anterior commissure ; C.H., cerebral hemisphere ; Inf., infundibulum ; L.T., lamina terminalis ; O.Ch., optic chiasma ; P.O.R., postoptic recess ; Pr.O.R., pre-optic recess.

OPTIC LOBES (MESENCEPHALON)

It is the most conservative region of the brain (Figs. 1 & 2, O. L.). Its dorsal part consists of two large, rounded optic lobes. The ventral surface is raised up into a pair of ridges, the crura cerebri, formed of a mass of longitudinal nerve fibres. Each optic lobe contains a cavity, the optocoel. The thickenings of the mesencephalic walls reduce the cavity of this region to a narrow canal, the aqueduct, which connects the third ventricle with the fourth. The optic lobes are partially covered posteriorly by the cephalic surface of the cerebellum.

CEREBELLUM (METENCEPHALON)

The cerebellum is of the primitive type as in other reptiles and is a mere vertical plate, hanging over the anterior part of the fourth ventricle. It is neither extroverted as in *Sphenodon* (Hindenach, 1931) nor are its

lateral margins everted as in *Testudo geometrica* (Schepers, 1938). The cerebellum is roughly triangular in shape; its apex extends forwards almost to the dorsal sac, while its base is more or less free. The cerebellum is attached to the underlying parts of the brain by means of narrow bridges, one at each angle at the sides of the base. The cerebellum is concave antero-posteriorly. In the centre of the cephalic surface there is a deep depression, which causes the posterior caudal surface to bulge out in the form of a hump. This swelling hides the fourth ventricle from view and fits, like a ball in the socket, in the depression on the dorsal surface of the ascending limb of the medulla. In *Uromastix hardwickii*, the masses of choroid tissue, which hang on each side in the fourth ventricle, cannot be distinguished below the cerebellar fold as in *Testudo geometrica*. In the sagittal section also the cerebellum is triangular, tapering gradually from the base to the apex. The stratum moleculare and stratum granulare take equal part in its formation. The anterior half is formed of the former and the posterior half of the latter. A longitudinal furrow is very distinct on the posterior surface of the cerebellum. This furrow or sulcus divides the cerebellum into two symmetrical halves and is possibly reminiscent of its bilateral origin. The sulcus is deepest above and below the above-mentioned hump, and gradually becomes less marked as it passes towards the apex; but the lower portion remains fairly well marked throughout its whole course. The part of the sulcus below the hump lies on a centrally placed ridge in the lower half of the cerebellum.

MEDULLA OBLONGATA (MYELENCEPHALON)

The medulla oblongata is broad in front and tapers behind where it passes into the spinal cord. The dorsal and ventral spinal fissures can be traced on both the surfaces of the medulla. The dorsal fissure continues forwards to about one-third of the medulla where it opens out leaving a triangular non-nervous region. This region is overlapped anteriorly by cerebellum and is covered over by the highly vascular pia mater, to form the posterior choroid plexus which hangs in the metacoel or fourth ventricle. The ventral fissure terminates at the anterior end of the medulla. The medulla oblongata is not straight, but ascends in close contact with the caudal surface of the cerebellum. On reaching the middle of the cerebellum this ascending limb becomes horizontal and passes out into the spinal cord posteriorly. As a result of this flexure of the medulla, the posterior choroid tissue on each side cannot be distinguished behind the cerebellum.

SUMMARY

1. In this paper the external morphology of the brain of *Uromastix hardwickii* Gray is described.

2. The fore- and mid- brain are large and contrast sharply with the cerebellum which is a small vertical plate.
3. The olfactory bulbs are pedunculated.
4. Various sulci found on the cerebral hemispheres are described and compared with those of other reptiles.
5. The sulci, fissura limitans, and endorhinal fissure of cerebrum are constant enough to be of comparative morphological value.
6. There is one large anterior commissure which lies in the lamina terminalis.
7. The important recesses of the third ventricle have been described.
8. The interventricular foramen is very prominent.
9. The dorsal sac is very complicated and encloses two epiphysial structures and the choroid plexus invaginating in the lateral ventricle.
10. The medulla is in contact with the caudal surface of the cerebellum thus hiding the choroid plexus.

REFERENCES

- Cairney, J., 1926. A general survey of the forebrain of *Sphenodon punctatum*. J. Comp. Neurol., **42** : 255-348.
- Goldby, F., 1934. The cerebral hemispheres of *Lacerta viridis*. J. Anat. Lond., **68** : 157-215.
- Herrick, C. J., 1910. The morphology of the forebrain in Amphibia and Reptilia. J. Comp. Neurol., **20** : 413-546.
- Hindenach, J. C. R., 1931. The cerebellum of *Sphenodon punctatum*. J. Anat. Lond., **65** : 283-298.
- Islam, A., 1955. The skull of *Uromastix hardwickii* Gray. Biologia, **1** (2) : 141-196.
- Johnston, J. B., 1913. The nervus terminalis in reptiles and mammals. J. Comp. Neurol., **23** : 371-478.
- , 1915. Cell masses of the forebrain of *Cistudo carolina*. J. Comp. Neurol., **25** : 393-468.
- Kappers, C. U. A., 1921. *Vergleichende Anatomie des Nervensystems*. Haarlem.

- de Lange, S. J., 1911. Das Vorderhirn der Reptilien. *Folia neurobiologica* Haarlem, **5** : 548-597.
- Schepers, G. W. H., 1938. The external morphology of the brain of *Testudo geometrica*. *J. Anat. Lond.*, **72** : 535-555.
- Smith, G. E., 1899. Further observations on the brain of Monotremata. *J. Anat. Physiol. norm. path.*, **33** : 309-342.
- , 1903. On the morphology of the cerebral commissures in the Vertebrata, with special reference to an aberrant commissure found in the forebrain of certain reptiles. *Tr. Linn. Soc. Lond.*, 2, viii, 455-500.
- , 1919. A preliminary note on the morphology of corpus striatum and origin of the neopallium. *J. Anat. Lond.*, **53**.
- Unger, L., 1906. Untersuchungen über die Morphologie und Faserung des Reptiliengehirns. *Anat. Hefte Wiesbaden, Abt. 1*, **31** : 269-311.

Culture of Algae of the Rice-fields of Kashmir

SHAMS-UL-ISLAM KHAN

INTRODUCTION

The observations on the culture of algae reported in this paper are in continuation of those already reported in an earlier paper on the "Algae of the Rice-fields of the Punjab". Through the kind courtesy of Dr H. Chaudhuri a few samples of soil from the rice-fields of Kashmir (Srinagar), were received for the cultivation of algae in the laboratory, and since the samples were in cloth bags, the soil from the different depths was all mixed up. Accordingly therefore, the culture work was done only by using different culture media, e. g., Beyerinck's, Bristol's, Detmer's, Knop's, and Uspenski's. Soil of each sample was thoroughly mixed and samples weighing one, two, and five grams were inoculated in the sterilized culture medium in milk bottles. All necessary precautions regarding the preparation of distilled water, culture medium, sterilization, inoculation etc., were observed and the bottles were kept in the glass house for the growth of algae.

OBSERVATIONS

Usually a thin whitish scum of bacterial growth appears on the surface of culture solutions in almost all the bottles but it is much less in Detmer's solution. The blue-green forms appear first in Detmer's and Bristol's media, but the green forms appear first in Uspenski's solution. In this medium in most of the bottles the unicellular forms appear earlier than the filamentous forms. Amongst the unicellular forms, *Chlamydomonas*, *Chlorococcum*, *Chlorella* and *Euglena* are common. A little later along with these, species of *Navicula* and *Mastogloia*, have also been observed. The filaments of *Oedogonium* appear and develop rapidly, but in such bottles in which their development is delayed, filaments of *Spirogyra* and other filamentous forms grow either as free-floating filaments on the surface of the culture medium or along the walls of the bottles. In Uspenski's medium the blue-green forms are the last to appear, and of these, *Phormidium*, *Oscillatoria*, and *Chroococcus* develop first.

In Detmer's and Bristol's media however, the sequence of development is just the reverse, for in these the blue-green forms like *Phormidium*, *Oscillatoria* and *Lyngbya* appear first, and then create conditions favourable for the growth of other delicate forms of Myxophyceae. It is then that species of *Calothrix*, *Plectonema* etc., start growing. In some bottles however, species of *Anabaena* and *Chroococcus* develop earlier than the filamentous blue-greens, and in such bottles the green forms also appear earlier than in those in which the membranous growth of *Phormidium* has often delayed their development considerably.

The developmental behaviour in Beyerinck's and Knop's solutions is of an intermediate character. In both however, the frequency of the green forms is more than that of the blue-green forms. The observations of these cultural experiments also show that the culture media of Uspenski's, Beyerinck's and Knop's are favourable for the growth of the green forms and those of Bristol and Detmer are suitable for the development of the blue-green forms. Further from table 1, it is evident that the maximum number of forms, whether green or blue-green, appears in those cultures in which only one gram of the soil is used for inoculation, but those which are inoculated with two and five grams of soil show the development of progressively fewer forms. When five grams of the soil are used for inoculation, in Detmer's solution, the green forms do not develop at all. Likewise the blue-green do not appear in Knop's and Uspenski's solutions under similar conditions. It is therefore a significant result that the use of a lesser quantity of soil promotes a better and a more varied growth of algal forms in cultivation, although the usual tendency is to use a larger quantity of soil to permit the growth of many more forms. This is further borne out by the fact that the use of a culture medium, particularly Detmer's and Bristol's, in $\frac{1}{2}$ and 1:3 dilution renders it more favourable for the growth of most algae.

From the above observations it is clear that the green forms prefer solutions of low concentrations and the blue-green forms grow better in solutions of high concentrations. This may directly be related to the presence of mucilage in the latter. Besides the nature of the culture medium and the quality of soil used for inoculation, the growth of algae is also markedly influenced by the quantity of the culture medium and aeration of the cultures. The growth of different algae, particularly of a variety of forms, depends much on the favourable combination of these factors. Further it has been observed that certain forms show a surprisingly strong reaction to the presence of some salts, e. g., *Spirogyra* will not

grow in any medium containing even traces of copper and a healthy culture of *Pandorina morum* will be killed overnight with only the minutest traces of Sodium Chloride.

When a culture becomes old, it then begins to show signs of deterioration. *Pleurococcus* is usually the first to form orange or brownish-red spores. Similarly many other algae behave in a like manner when the period of active vegetative growth comes to an end. This however, can be delayed by keeping the cultures in diffused light at low temperatures. If the culture, as a result of excessive evaporation has very little water left in it, sterilized distilled water may be added to avoid complete drying. Observations on old cultures are interesting, particularly from the point of view of periodicity. During the course of this culture work, it has been observed that species of *Oscillatoria*, *Phormidium* and *Lyngbya* started growing again after an interval of six months, after they had virtually disappeared from the same culture earlier.

SYSTEMATIC ENUMERATION OF SPECIES

I-CHLOROPHYCEAE

ISOKONTAE (Fam. CHLAMYDOMONADACEAE)

Genus *Chlamydomonas* Ehrbg.

1. *Chlamydomonas angulosa* Dill.

Pascher, Suss. Deut. Oster. Schw., 1927; 4 : 235, fig. 179.

It grows luxuriently in Uspenski's and Beyerinck's solutions.

2. *Chlamydomonas nivalis* Wille.

Pascher, Suss. Deut. Oster. Schw., 1927 ; 4 : 196, fig. 136.

It grows luxuriently in Uspenski's and Beyerinck's solutions.

Genus *Pandorina* Bory

3. *Pandorina morum* (Muller) Bory.

Pascher, Suss. Deut. Oster. Schw., 1927 ; 4 : 427, fig. 387.

Its growth is abundant in Uspenski's solution.

Genus *Gonium* Muller

4. *Gonium pectorale* Muller

Pascher, Suss. Deut. Oster. Schw., 1927 ; 4 : 418, fig. 376.

Its growth is abundant, in Uspenski's solution.

5. *Gonium sociale* (Duj.) Warming

Pascher, Suss. Deut. Oster. Schw., 1927 ; 4 : 420, fig. 381.

It grows well in Uspenski's and Beyerinck's solutions.

Genus *Chlorogonium* Ehrbg.6. *Chlorogonium elongatum* Dang.

Pascher, Suss. Deut. Oster. Schw., 1927 ; 4 : 316, fig. 283.

It grows well in Uspenski's and Beyerinck's solutions.

Genus *Sphaerocystis* Chodat7. *Sphaerocystis schroeteri* Chodat

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 31, fig. 8.

It is planktonic and forms colonies which are smaller in size than the type species.

Genus *Asterococcus* Scherf.8. *Asterococcus superbus* (Clenk.) Scherf.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 33, fig. 30.

It grows well in Beyerinck's solution but the lamellations of the mucilage envelope usually do not develop.

Genus *Gloeocystis* Naegeli9. *Gloeocystis vesiculosa* Naegeli

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 35, fig. 10.

It is a very common alga and grows luxuriently in Knop's and Beyerinck's solutions.

Genus *Chlorococcum* Fries10. *Chlorococcum infusionum* (Schrank) Menegh.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 62, fig. 2.

Genus *Characium* Braun11. *Characium naegeli* Braun

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 82, fig. 29.

It grows as epiphyte on *Oedogonium globosum* Nordst.

12. *Characium nasutum* Rabenh.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 78.

In culture it grows as sessile and with a broad base, on the filaments of *Oedogonium* sp. The size of the cells is smaller and may be distinguished as variety *sessilis*.

Genus *Pediastrum* Moya13. *Pediastrum tetras* (Ehrbg.) Ralfs.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 103, fig. 64.

Its growth is luxurient in Uspenski's solution.

Genus *Chlorella* Beij.14. *Chlorella vulgaris* Beij.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 111. fig. 71.

A very common alga in the rice fields.

Genus *Trochiscia* Kuetz.15. *Trochiscia aspera* (Reinsch.) Hansg.

Pascher. Suss. Deut. Oster. Schw., 1915 ; 5 : 204.

Genus *Oocystis* Naegeli16. *Oocystis marssonii* Lemm.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 125, fig. 100.

17. *Oocystis rupestris* Kirchn.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 124, fig. 93.

Common in the rice fields

Genus *Nephrocytium* Naegeli18. *Nephrocytium lunatum* West

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 140, fig. 114.

The mucilage sheath is well developed but in culture the size of the cells remains smaller.

Genus *Dactylococcus* Naegeli19. *Dactylococcus bicaudatus* Braun

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 216.

Fairly common in the rice fields.

Genus *Ankistrodesmus* Corda20. *Ankistrodesmus falcatus* (Corda) Ralfs., var. *acicularis* West

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 188, fig. 284.

Genus *Selenastrum* Reinsch.21. *Selenastrum minutum* (Naegeli) Collins

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 182, fig. 272.

Genus *Scenedesmus* Moyer22. *Scenedesmus quadricauda* (Turpin) Breb.

Pascher, Suss. Deut. Oster. Schw., 1915 ; 5 : 165, fig. 223.

Abundant in the rice fields.

Genus *Uronema* Lagerh.23. *Uronema confervicolum* Lagerh.

Pascher, Suss. Deut. Oster. Schw., 1914 ; 6 : 36, fig. 37.

In culture the filaments show a tendency to pass into palmella state and often show a variable thickness of the cell wall.

Genus *Microspora* Thuret24. *Microspora stagnorum* (Kuetz.) Lagerh.

Pascher, Suss. Deut. Oster. Schw., 1914 ; 6 : 151, fig. 210.

Genus *Aphanochaete* Braun25. *Aphanochaete repens* Braun

Pascher, Suss. Deut. Oster. Schw., 1914 ; 6 : 128, fig. 179.

Genus *Stigeoclonium* Kuetz.26. *Stigeoclonium nanum* Kuetz.

Pascher, Suss. Deut. Oster. Schw., 1914 ; 6 : 74, fig. 97.

27. *Stigeoclonium tenue* Kuetz.

Pascher, Suss. Deut. Oster. Schw., 1914 ; 6 : 78, fig. 111.

Grows on the surface of the floating membranes of *Phormidium angustissimum* West & West, in the culture bottles.Genus *Gongrosira* Kuetz.28. *Gongrosira stagnalis* (West) Schmid.

Pascher, Suss. Deut. Oster. Schw., 1914 ; 6 : 108, fig. 158.

It forms extensive patches on the sides of the culture bottles, submerged or exposed, and sometimes on the surface of the soil at the bottom.

Genus *Pleurococcus* Menegh.29. *Pleurococcus viridis* Agardh

Pascher, Suss. Deut. Oster. Schw., 1914 ; 6 : 224.

Most abundant in the soils of rice fields.

Genus *Oedogonium* Link30. *Oedogonium globosum* Nordst

Tiffany, Oedogoniaceae, 1930; 74; fig. 130.

Grows attached to the sides of culture bottles.

31. *Oedogonium urticum* Wittr.

Tiffany, Oedogoniaceae, 1930, 69, fig. 118.

Quite common in the rice fields.

Genus *Spirogyra* Link.32. *Spirogyra* sp. 1.

Vegetative cell 170-200 μ long and 115-120 μ broad ; cross walls simple ; three bands of chloroplasts in each cell.

33. *Spirogyra* sp. 2.

Vegetative cell 70-90 μ long and 30 μ broad ; cross walls replicate ; two bands of chloroplasts with 1-1½ turns in each cell.

Genus *Closterium* Nitzsch34. *Closterium moniliferum* (Bory) Ehrbg.

Rabenhorst, Krypt. Fl., 1930 ; 13-1/2 : 289, fig. 6, 7.

Very common in the rice fields.

Genus *Cosmarium* Corda35. *Cosmarium undulatum* Corda

W. & G. S. West, Mon. Brit. Desmidiaceae, II, 1905, 148, fig. 1-5.

Rather rare in the rice fields.

Genus *Chara* Vaillant36. *Chara contraria* (Braun) Kuetz.

J. Groves, Ind. Charophyta, J. Linn. Soc. Bot., 1923, 49 : 262.

HETEROKONTAE

Genus *Mischococcus* Naegeli37. *Mischococcus confervicola* Naegeli

Pascher, Suss. Deut. Oster. Schw., 1925 ; 11 : 37, fig. 20.

II-BACILLARIOPHYCEAE

CENTICAE

Genus *Melosira* Agardh1. *Melosira varians* Agardh

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 13, fig. 2.

Genus *Coscinodiscus* Ehrbg.2. *Coscinodiscus excentricus* Ehrbg.

Rabenhorst, Krypt. Fl., 1930 ; 7/1 : 397.

PENNATAE

Genus *Synedra* Ehrbg.3. *Synedra radians* Kuetz.

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 40, fig. 62.

Genus *Diploneis* Ehrbg.4. *Diploneis elliptica* Kuetz.

Rabenhorst, Krypt. Fl., 1930 ; 7/2 : 355

Genus *Mastogloia* Thwaites5. *Mastogloia braunii* Grunow

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 63, fig. 116.

Genus *Navicula* Bory6. *Navicula lanceolata* Kuetz.

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 96, fig. 202.

Genus *Anomoioneis* Pfitz.7. *Anomoioneis sculpta* Ehrbg.

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 88, fig. 175.

Genus *Gomphonema* Agardh8. *Gomphonema olivaceum* Lyngb.

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 125, fig. 272.

Genus *Cymbella* Agardh9. *Cymbella parva* Smith

Pascher; Suss. Deut. Oster. Schw., 1913 ; 10 : 135, fig. 294.

Genus *Epithemia* Breb.10. *Epithemia sorex* Kuetz.

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 145, fig. 319.

Genus *Nitzschia* Hassall11. *Nitzschia stagnorum* Rabenh.

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 153, fig. 337.

12. *Nitzschia linearis* (Agardh) Smith

Pascher, Suss. Deut. Oster. Schw., 1913 ; 10 : 156, fig. 345.

III-EUGLENINÆ

Genus *Euglena* Ehrbg.1. *Euglena proxima* Dang.Pascher, Suss. Deut. Oster. Schw., 1913 ; 2 : 129, fig. 193.
Very common in the rice fields.2. *Euglena viridis* Ehrbg.

Pascher, Suss. Deut. Oster. Schw., 1913 ; 2 : 127, fig. 189.

IV-MYXOPHYCEÆ

Genus *Microcystis* Kuetz.

1. *Microcystis marginata* (Menegh.) Kuetz.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 136, fig. 59.
2. *Microcystis aeruginosa* Kuetz.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 197, fig. 59d.

Genus *Aphanocapsa* Naegeli

3. *Aphanocapsa koordersi* Strom.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 155, fig. 68.

Genus *Gloeocapsa* Kuetz.

4. *Gloeocapsa granosa* Kuetz.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 188, fig. 84.
Grows exposed on the sides of culture bottles. Certain colonies which can be distinguished as forma *major*, develop cells which are twice as large as those of the type species, and the mucilage cover around the colony is also diffuent.
5. *Gloeocapsa conglomerata* Kuetz.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 189, fig. 82.
It is a very hardy form and can survive severe exposure and drying, and often grows well on moist soil.

Genus *Chroococcus* Naegeli

6. *Chroococcus turgidus* (Kuetz.) Naegeli
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 228, fig. 109.
7. *Chroococcus minutus* (Kuetz.) Naegeli
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 232, fig. 112a.

Genus *Coelosphaerium* Naegeli

8. *Coelosphaerium goetzei* Schmid.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 254.

Genus *Eucapsis* Clements et Schantz.

9. *Eucapsis alpina* Clements et Schantz.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 258, fig. 126.

Genus *Merismopedia* Moyn

10. *Merismopedia tenuissima* Lemm.
Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 263, fig. 129.

Genus *Synechococcus* Naegeli11. *Synechococcus maior* Schroet.

Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 272.

The cells in the forms observed are larger in size than even in the var. *maximum*. This then may be distinguished as var. *major*.

Genus *Dactylococcopsis* Hansg.12. *Dactylococcopsis irregularis* Smith

Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 282, fig. 138a.

13. *Dactylococcopsis acicularis* Lemm.

Rabenhorst, Krypt. Fl., 1930 ; 14/1 : 285.

Genus *Calothrix* Agardh14. *Calothrix gracilis* Fritsch

Rabenhorst, Krypt. Fl., 1931 ; 14/3 : 614, fig. 387.

Very common in the rice fields.

15. *Calothrix brevissima* West

Rabenhorst, Krypt. Fl., 1931 ; 14/3 : 624, fig. 396.

Grows epiphytically on the filaments of *Oedogonium* sp.Genus *Plectonema* Thuret16. *Plectonema phormidioides* Hansg.

Rabenhorst, Krypt. Fl., 1932 ; 14/4 : 690.

It forms submerged mucilaginous masses on the soil surface in culture. Very often the cells of the trichomes show marked constrictions at the cross walls.

17. *Plectonema boryanum* Gomont

Rabenhorst, Krypt. Fl., 1932 ; 14/4 : 693.

Grows along the sides of the culture bottles.

Genus *Nostoc* Voucher18. *Nostoc entophytum* Bornet & Flah

Rabenhorst, Krypt. Fl., 1932 ; 14/4 : 836.

Planktonic in the culture bottles.

19. *Nostoc commune* Voucher

Rabenhorst, Krypt. Fl., 1932 ; 14/4 : 845, fig. 537.

Genus *Anabaena* Bory20. *Anabaena indica* Beck

Rabenhorst, Krypt. Fl., 1932 ; 14/4 : 899.

Genus *Spirulina* Turpin

21. *Spirulina platensis* (Nordst.) Geitl.
Rabenhorst, Krypt. Fl., 1932; 14/5 : 925, fig. 590.

Genus *Oscillatoria* Voucher

22. *Oscillatoria limosa* Agardh.
Rabenhorst, Krypt. Fl., 1932; 14/5 : 944, fig. 598.
An extremely common alga with a very wide range of growth.
23. *Oscillatoria tenuis* Agardh.
Rabenhorst, Krypt. Fl., 1932 ; 14/5 : 959, fig. 611.
24. *Oscillatoria obscura* Bruhl
Rabenhorst, Krypt. Fl., 1932; 14/5 : 945.
25. *Oscillatoria princeps* Vouch.
Rabenhorst, Krypt. Fl., 1932; 14/5 : 946, fig. 598.

Genus *Phormidium* Kuetz.

26. *Phormidium angustissimum* West & West
Rabenhorst, Krypt. Fl., 1932; 14/5 : 996.
An extremely hardy and widely distributed alga, with a wide range of growth.
27. *Phormidium frigidum* Fritsch
Rabenhorst, Krypt. Fl., 1932; 14/5 : 997.
28. *Phormidium africanum* Lemm.
Rabenhorst, Krypt. Fl., 1932; 14/5 : 999.
It forms extensive sheets in the culture bottles.
29. *Phormidium molle* Gom., forma *tenuior* West & West
Rabenhorst, Krypt. Fl., 1932; 14/5 : 1001.
30. *Phormidium ambiguum* Gom.
Rabenhorst, Krypt. Fl., 1932; 14/5 : 1015, fig. 647.

Genus *Lyngbya* Agardh.

31. *Lyngbya meneghiniana* Gom.
Rabenhorst, Krypt. Fl., 1932; 14/5 : 1040.
32. *Lyngbya halophila* Hansg.
Rabenhorst, Krypt. Fl., 1932; 14/6 : 1057.
33. *Lyngbya semiolena* Agardh
Rabenhorst, Krypt. Fl., 1932; 14/6 : 1061, fig. 672.
34. *Lyngbya putealis* Mont.
Rabenhorst, Krypt. Fl. 1932; 14/6 : 1063, fig. 675b.

Genus *Aulosira* Kirch.35. *Aulosira africana* Lemm.

Rabenhorst, Krypt. Fl., 1932; 14, 4 : 675.

ACKNOWLEDGEMENTS

It is with a deep sense of gratitude and appreciation that the writer wishes to express his indebtedness to Dr H. Chaudhuri and Dr P. L. Anand for their willing and liberal guidance and help offered during the course of this research, while at the University of the Panjab.

SUMMARY

Algae of the rice fields near Srinagar, Kashmir, are described. These were grown in the laboratory in culture bottles from soil samples in different culture media.

Observations on the growth of algae in culture are described, particularly the sequence in which the different types appear in a culture bottle or in a particular culture medium.

All the different species of algae which have been observed to grow in culture, have been enumerated in a systematic manner and the distribution of these in the different classes is as given below :

- | | |
|-----------------------|---------------------------|
| 1. Chlorophyceae - 37 | 2. Bacillariophyceae - 12 |
| 3. Euglenineae - 2 | 4. Myxophyceae - 35 |

Of these the following show a distinctive form in culture.

1. *Asterococcus superbus* (Cienk.) Scherf.
2. *Characium nasutum* Rabenh.
3. *Gloeocapsa granosa* Kuetz.
4. *Synechococcus maior* Schroet.

APPENDIX

(CULTURE MEDIA)

1. **Beyerinck's Culture Medium** :- (pH value - 7.2)

NH_4NO_3	- 0.05 gm.	KH_2PO_4	- 0.02 gm.
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	- 0.02 gm.	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$	- 0.01 gm.
FeCl_3	- One drop	Dist. Water	- 1000 c. c.
of 1% solution			

2. **Bristol's Culture Medium** :- (pH value - 5.2)

KH_2PO_4	- 1.0 gm.	CaCl_2	- 0.1 gm.
NaNO_3	- 1.0 gm.	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	- 0.3 gm.
NaCl	- 0.1 gm.	FeCl_3	- 0.01 gm.
		Dist. Water	- 1000 c.c.

SPECIFIC NAMES	Beyerinck			Bristol			Detmer			Knop			Uspenski		
	5	2	1	5	2	1	5	2	1	5	2	1	5	2	1
	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm
21. Selenastrum minutum			x			x					x				x
22. Scenedesmus quadricauda		x	x						x		x				x
23. Uronema confervicolum		x	x												
24. Microspora stagnorum			x								x	x			x
25. Aphanochaete repens			x								x				x
26. Stigeoclonium nanum			x								x				x
27. S. tenue			x								x			x	x
28. Gongrosira stagnalis		x									x				
29. Pleurococcus viridis	x	x	x	x	x	x	x	x		x	x	x	x	x	x
30. Oedogonium globosum		x	x								x	x			x
31. O. urbicum			x								x				x
32. Spirogyra sp. (1) *														x	x
33. Spirogyra sp. (2) *			x											x	x
34. Closterium moniliferum		x												x	x
35. Cosmarium undulatum														x	
36. Chara contraria			x								x			x	x
37. Mischococcus confervicola			x			x									
38. Melosira varians			x								x				
39. Coscinodiscus excentricus			x												
40. Synedra radians			x												x
41. Diploneis elliptica		x													x
42. Mastogloia braunii			x			x			x					x	
43. Navicula lanceolata			x			x			x		x			x	x
44. Anomoioneis sculpta			x						x						x
45. Gomphonema olivaceum			x			x					x			x	x
46. Cymbella parva											x				x
47. Epithemia sorex															x
48. Nitzschia stagnorum						x	x		x					x	x
49. N. linearis						x									x
50. Euglena proxima															x
51. E. viridis											x			x	x
52. Microcystis marginata		x	x			x			x		x			x	x
53. M. aeruginosa															x
54. Aphanocapsa koordersi							x		x	x					
55. Gloeocapsa granosa						x	x		x	x	x				
56. G. conglomerata							x		x	x					
57. Chroococcus turgidus						x	x	x	x	x	x				
58. C. minutus		x				x				x					
59. Coelosphaerium goetzei			x							x					x
60. Eucapsis alpina			x				x							x	x
61. Merismopedia tenuissima						x	x								x
62. Synecococcus maior									x	x	x				
63. Dactylococcoopsis irregularis															x
64. D. acicularis			x				x			x	x				
65. Calothrix gracilis			x			x	x			x					
66. C. brevissima			x												
67. Plectonema phormidioides									x						
68. P. boryanum									x	x					
69. Nostoc entophyllum						x				x					
70. N. commune									x	x					
71. Anabaena indica			x							x					
72. Spirulina platensis															
73. Oscillatoria limosa			x			x			x	x	x				x
74. O. tenuis	x	x	x			x	x			x		x			
75. O. obscura						x	x			x					x
76. O. princeps			x	x					x	x		x			
77. Phormidium frigidum										x			x		x
78. P. angustissimum	x	x	x			x	x		x	x	x		x	x	x

* Species not determined

SPECIFIC NAMES	Beyerinck	Bristol	Detmer	Knop	Uspenski
	5 2 1 gm gm gm	5 2 1 gm gm gm	5 2 1 gm gm gm	5 2 1 gm gm gm	5 2 1 gm gm gm
79. <i>P. africanum</i>	x		x		x
80. <i>P. molle form tenuior</i>	x	x x	x x	x	x
81. <i>P. ambiguum</i>	x	x x	x x		
82. <i>Lyngbya putealis</i>	x			x	
83. <i>L. semiplena</i>		x			
84. <i>L. halophila</i>	x		x x		
85. <i>L. meneghiniana</i>	x	x	x x	x	
86. <i>Aulosira africana</i>		x	x x	x	

SUMMARY OF TABLE 1.

CLASS	Beyerinck	Bristol	Detmer	Knop	Uspenski
	5 2 1 gm gm gm	5 2 1 gm gm gm	5 2 1 gm gm gm	5 2 1 gm gm gm	5 2 1 gm gm gm
1. Chlorophyceae	6 19 29	1 4 6	0 4 5	0 14 17	6 16 31
2. Bacillariophyceae	0 1 7	0 3 3	0 1 3	0 0 4	0 4 10
3. Euglenineae	0 0 0	0 0 0	0 0 0	0 0 1	1 1 2
4. Myxophyceae	2 6 17	3 10 18	5 19 25	0 4 5	0 3 12
Total	6 23 53	4 17 27	5 24 33	3 18 27	7 24 55

REFERENCES

- Bold, H.C., 1942. The Cultivation of Algae. *Bot. Rev.* **8** : 2.
- Collins, F.S., 1928. *Green Algae of North America*.
- Fritsch, F.E., 1923. A Contribution to our Knowledge of Algae of S. Africa. *Trans. Roy. Soc. S. Africa*, II.
- Ghose, S.L. 1927. The Myxophyceae of Rangoon, I-III, *Jour. Burma Res. Soc.* **17** : 242.
- Groves, J., 1923. Indian Charophyta, *Jour. Linn. Soc. Bot.* **49**.
- Pascher, A., 1914-1927. *Die Susswasser Flora der Deutschlands, Osterreichs und der Schweiz*. Heft 1-12.
- Rabenhorst, L. 1930-32. *Kryptogamen Flora*. Band 7-14.
- Smith, G.M., 1933. *Freshwater Algae of the United States*.
- Tilden, J., 1910. *Minnesota Algae*. Vol. I.
- Triffany, L.H., 1938. *Oedogoniaceae*.
- West, G.S. & Fritsch, F.E., 1932. *A Treatise on the British Fresh-water algae*.
- West, W. & West, G.S., 1905. *A Monograph of British Desmidiaceae*.

A list of the mosses of West Pakistan

ASGHAR ALI, M.Sc.

Lawrence College, Ghora Gali.

The moss flora of West Pakistan is comparatively little known. The present list is an attempt to bring together the records published in journals not easily accessible to an ordinary student of the group. It is hoped that it will help in reviving interest in this group, which has been somewhat neglected in this country for the last ten years.

The mosses listed represent the collections of Tirich Mir Expedition and of Duthie from Chitral, Garrett and Lillie from the Kagan Valley and Sultan Ahmad from Swat State and Murree Hills. The records from the plains are based on the collections preserved in the Herbarium of the Panjab University. No records are available from the former provinces of Sind and Baluchistan.

This list comprises 67 genera and 131 species arranged in an alphabetical order.

The scheme of classification followed is that of Brotherus in Engler & Prantl's *Pflanzenfamilien* Bd. 10 & 11, 1924-25.

BIBLIOGRAPHY

- 1898. Brotherus, V.F. Contributions to the Bryological Flora of the North Western Himalaya. *Acta Soc. Sci. Fenn.* **24** : 1-43.
- 1926. Dixon, H.N. Mosses collected in Gilgit, etc. by Garrett and W. Lillie. *Rec. Bot. Survey of India* **9** : 303-313.
- 1931. Brühl, P. A Census of Indian Mosses. *Rec. Bot. Surv. of India* **13** (1) : 1-135.
- 1938. Herzog, Th. Bryophyta. In *Botanische Ergebnisse der Deutschen Hindukusch-Expedition 1935*. Herausgegeben von I. Haeckel und W. Troll. Lief. 1.- Rep. Spec. Nov. regn. veg. Beih. Bd. 108, 1.
- 1954. Stoermer, Per. Mosses from Tirich Mir. A contribution to the Bryology of N.W. Pakistan. *Nytt. Mag. f. Bot.* **2** : 213-226.
- 1956. Noguchi, A. Mosses from Pakistan. *J. Hattori Bot. Lab. No.* 16, pp. 75-82.

SUB-CLASS : BRYALES

I. Order : FISSIDENTALES

FISSIDENTACEAE

Fissidens Hedw.

F. chitralensis P. de la Varde; Stoermer, p. 214. Chitral.

F. diversifolia Mitt. Jhelum; Lahore.

F. grandifrons Brid.; Dixon, p. 305; Noguchi, p. 75. Hazara; Swat State; Changla Gali.

F. perplexans Dix.; Dixon, p. 395. Kagan Valley.

F. schmidii C.M.; Stoermer, p. 214. Chitral.

II. Order : DICRANALES

DICRANACEAE

Dichodontium Schimp.

D. pellucidum (Hedw.) Schimp.; Noguchi, p. 77. Swat; Changla Gali.

Dicranella Schimp.

D. rubra (Huds.) Moenk.; Noguchi, p. 77. Murree.

Trematodon Michx.

T. brevicalyx Dix. Lahore.

DITRICHACEAE

Ceratodon Brid.

C. purpureus (L.) Brid.; Stoermer, p. 218. Chitral.

Distichum Bryol. Eur..

D. capillaceum (Hedw.) Br. & Sch.; Stoermer, p. 518. Chitral.

— var. *compactum* (Hueh.) Dix. Chitral.

D. inclinatum (Ehrh.) Bryol. Eur.; Stoermer, p. 218. Chitral.

SELIGERACEAE

Blindia Bryol. Eur.

B. perminuta Noguchi; Noguchi, p. 72. Murree.

III. Order : POTTIALES

POTTIACEAE

Aloina (C. Muell.) Kindb.

A. stellata (Schreb.) Kindb.; Noguchi, p. 72. Swat : Madian, Barikot.

Astomum Hamp.

A. crispum (Hedw.) Lampr. var. *exsertum* Noguchi; Noguchi, p. 77.
Swat State : Mingora.

Barbula Hedw.

- B. alpigena* Vent.; Brotherus, p. 13. Chitral; Dir.
B. comosa Doz. & Molk; Noguchi, p. 77. Swat State.
B. consanguinoides Dix. Jhelum.
B. fallax Hedw.; Noguchi, p. 77. Swat State : Madian.
B. flavescens (Hook. & Grev.) Brid. Jhelum.
B. aff. gregaria Mitt.; Dixon, p. 308. Babusar Pass.
B. horricomis C. Mueller; Dixon, p. 307. Kagan Valley.
B. indica Brid. Jhelum; Gujrat.
B. javanica Doz. & Molk. var. *robusta* Dix.; Dixon, p. 307. Hazara.
B. recurvirostris (Hedw.) Dix.; Brotherus, p. 13; Stoermer, p. 219.
 Chitral : Bundai, Guger.
B. rubella (Hoff.) Broth.; Brotherus, p. 13. Chitral : Burdai, Guger;
 Dir.

Crossidium Jur.

- C. squamigerum* (Viv.) Jur.; Noguchi, p. 77. Swat State : Barikot.
C. chloronotos (Brid.) Limpr.; Noguchi, p. 78. Swat State : Barikot,
 Khaza Khela.

Desmatodon Brid,

- D. latifolius* (Hedw.) Bryol. Eur.; Noguchi, p. 78. Swat State : Mingora, Barikot; Chitral.
D. systilius Br. & Sch.; Stoermer, p. 219. Chitral.

Didymodon Hedw.

- D. rubellus* (Hoffm.) Bryol. Eur.; Brühl, p. 38. Kagan Valley.
D. rufescens (Hook.) Broth., Dixon, p. 307, Kagan Valley.

Eucladium Bryol. Eur.

- E. verticillatum* (L.) Bryol. Eur.; Brotherus. p. 7. Chitral : Mirkandi.

Gymnostomum Hedw.

- G. recurvirostrum* Hedw.; Noguchi, p. 77; Stoermer, p. 330. Chitral;
 Swat State.
G. rupestre Schleich.; Noguchi, p. 77. Changla Gali.

Hymenostomum R. Br.

- H. obscurissimum* Dix.; Dixon, p. 306. Kagan Valley.

Pleurochaete Lindb.

- P. squarrosa* (Brid.) Lindb.; Noguchi, p. 77. Swat State : Barikot.

Stegonia Vent.

- S. latifolia* (Schwaegr.) Vent.; Stoermer, p. 219. Chitral.

Timmiella (de Not.) Limpr.

- T. anomala* (Bryol. Eur.) Limpr.; Brotherus, p. 12; Dixon, p. 337; Noguchi, p. 77. Chitral; Dir Valley; Swat State : Barikot, Khaza Khela.

Tortella (C. Muell.) Limpr.

- T. tortuosa* (L.) Limpr.; Brotherus, p. 12; Noguchi, p. 77; Stoermer, p. 220. Chitral; Changla Gali.

Tortula Hedw.

- T. alpina* (Bryol. Eur.) Bruch.; Noguchi, p. 78. Changla Gali.
T. brandisii (C. M.) Broth.; Dixon, p. 308. Kagan Valley.
T. desertorum Broth.; Stoermer, p. 219.. Chitral.
T. inermis (Brid.) Mont.; Brotherus, p. 14; Noguchi, p. 78. Chitral : Bundai, Ashreth; Swat State : Barikot; Khaza Khela, Mingora.
T. montana (Nees) Lindb.; Brotherus, p. 14. Chitral : Ashreth.
T. ruralis (L.) Ehrh.; Brotherus, p. 14. Chitral; Lahore.

Trichostomum Hedw.

- T. lilliei* Dix.; Dixon, p. 306. Kagan Valley.

Weisia Hedw.

- W. tortilis* C. Muell.; Noguchi, p. 77. Swat State : Madian, Mingora.

ENCALYPTACEAE

Encalypta Schreb.

- E. vulgaris* (Hedw.) Hoffm.; var. *obtusa* Bryol. germ.; Stoermer, p. 219. Chitral.

Orthothecium Bryol. Eur.

- O. intricatum* (Hartm.) Bryol. Eur.; Brühl, p. 98. Panjab.

IV. ORDER : GRIMMIALES

GRIMMIACEAE

Grimmia Ehrh.

- G. ahmadiana* Noguchi; Noguchi, p. 79. Swat State : Khaza Khela.
G. anodon Br. & Sch.; Stoermer, p. 220. Chitral : Mirza, Lowari.
G. apocarpa (L.) Hedw.; Dixon, p. 308. Babusar Pass.
G. commutata Hueb.; Brotherus, p. 15; Dixon, p. 301; Noguchi, p. 79. Chitral : Mirza, Lowari; Kagan Valley; Swat State : Bahrain.
G. leucophaea Grev.; Brotherus, p. 15. Chitral : Bundai.
G. pulvinata (L.) Sm.; Brotherus, p. 15. Chitral; Chakdara.

V. Order: FUNARIALES

FUNARIACEAE

Funaria Schreb.

F. attenuata (Dicks.) Lindb.; Noguchi, p. 79. Swat : Barikot; Khaza Khela.

F. capillipes Broth.; Brotherus, p. 20. Chitral.

F. ericetorum Dix. Jhelum.

F. hygrometrica (L.) Sibth.; Dixon, p. 309; Noguchi, p. 80; Stoermer, p. 220. Chitral; Lahore; Changla Gali; Murree.

F. mediterranea Lindb.; Noguchi, p. 80. Swat State : Barikot.

Physcomitrium (Brid.) Fuernr.

Ph. cyathicarpum Mitt. Lahore; Jhelum.

Ph. repandum (Griff.) Mitt. Jhelum; Lahore.

VI. Order: EUBRYALES

BRYACEAE

Anomobryum Schimp.

A. nitidum (Mitt.) Jacq. Lahore.

Brachymerium Schwaegr.

B. indicum (Doz. & Molke) Bryol. Jav.; Dixon, p. 309. Kagan Valley.

Bryum Dill., Schimp.

B. argenteum Hedw.; Brotherus, p. 24; Dixon, p. 310; Stoermer, p. 221. Chitral : Bundai; Kagan Valley; Babusar Pass.

B. blindii Bryol. Eur.; Dixon, p. 310. Kagan Valley; Babusar Pass.

B. cellulare Hook.; Dixon, p. 309. Kagan Valley; Lahore; Jhelum.

B. pallescens Schleich.; Noguchi, p. 80. Swat State.

B. ramosum (Hook.) Mitt.; Noguchi, p. 80. Murree.

B. turbinatum (Hedw.); Brotherus, p. 26. Chitral : Ashreth, Guger.

B. ventricosum Dicks.; Dixon, p. 302. Babusar Pass.

Leptobryum (Bryol. Eur.) Wils.

L. pyriforme (Hedw.) Wils.; Brotherus, p. 20; Stoermer, p. 220; Noguchi, p. 86. Chitral; Swat State : Kalam.

Mielichhoferia Hornsch.

M. himalayana Mitt.; Stoermer, p. 221. Chitral.

Mniobryum (Schimp.) Limpr.

Mn. albicans (Wahlenb.) Limpr. Kagan Valley.

Pohlia Hedw.

P. albicans (Vahl) Lindb.; Noguchi, p. 80; Stoermer, p. 221. Chitral; Changla Gali.

- var. *glacialis* (Schleich.) Lindb.; Stoermer, p. 221. Chitral.
P. chitralensis Stoermer; Stoermer p. 221. Chitral.
P. cruda Hedw.; Stoermer, p. 221. Chitral.
P. ludwigii (Spreng.) Broth.; Noguchi, p. 80. Swat State.

Rhodobryum (Schimp.) Hamp.

- R. roseum* (Weis.) Limpr.; Noguchi, p. 81. Murree.

MNIACEAE

Mnium Dill.

- Mn. heterophyllum* Schwaegr.; Noguchi, p. 81. Murree.
Mn. medium Bryol. Eur.; Brotherus, p. 27. Chitral : Ziarat.
Mn. riparium Mitt.; Brotherus, p. 27; Stoermer, p. 223. Chitral.
Mn. rostratum Schrad.; Noguchi, p. 81. Changla Gali; Murree.

BARTRAMIACEAE

Bartramia Hedw.

- B. pomiformis* (L.) Hedw.; Noguchi, p. 81. Swat : Madian, Bahrain.
B. oederi (Gunn.) Sw.; Brotherus, p. 20. Chitral : Mirza.

Philonotis Brid.

- Ph. falcata* (Hook.) Mitt. Chitral : Mirza; Kurram Valley.
Ph. fontana (L.) Brid.; Dixon, p. 810; Stoermer, p. 223. Chitral;
Babuser Pass.
Ph. marchica (Willd.) Brid.; Stoermer, p. 224. Chitral.
Ph. turneriana (Schwaegr.) Mitt.; Noguchi, p. 81. Changla Gali;
Swat State.

TIMMIACEAE

Timmia Hedw.

- T. bavarica* Hessel.; Brotherus, p. 29; Noguchi, p. 81; Stoermer, p. 224. Chitral : Ziarat; Swat State.

VII. Order : ISOBRYALES

NECKERACEAE

Cryptoleptodon Ren. & Card.

- C. flexuosus* (Harv.) Ren. & Card.; Noguchi, p. 81. Changla Gali.

ORTHOTRICHACEAE

Drummondia Hook.

- D. thomsoni* Mitt.; Brotherus, p. 16; Noguchi, p. 81. Chitral :
Dir Valley; Swat State : Barikot.

Orthotrichum Hedw.

O. anomalum Hedw.; Brotherus, p. 10. Chitral : Mirza, Lowari.

VIII Order : **HOOKERIALES**

HYPOPTERYGIACEAE

Hypopterygium Brid.

H. tibetanum Mitt.; Noguchi, p. 81. Murree.

IX. ORDER : **HYPNOBRYALES**

AMBLYSTEGIACEAE

Amblystegium Bryol. Eur.

A. filicinum (L.) Lindb.; Brotherus, p. 38. Chitral : Bundai, Broz; Parachinar in Kurram Valley.

A. serpens (L.) Bryol. Eur.; Brotherus, p. 40. Chitral : Guger. Jamabatai, Ashreth, Ziarat.

Cratoneurum (Sull.) Roth.

C. commutatum (Hedw.) Roth.; Stoermer, p. 224. Chitral.

———var. *falcatum* (Brid.) Moenkem.; Herzog, p. 11. W. Chitral.

C. filicinum (Hedw.) Roth.; Brotherus, p. 38; Herzog, p. 11; Noguchi, p. 82; Stoermer, p. 225. Chitral; Murree; Swat State : Kalam; Changla Gali.

———var. *curvicaule* (Jur.) Mol.; Stoermer, p. 225. Chitral.

———var. *fallax* (Brid.) Moenkem.; Stoermer, p. 225. Chitral.

Drepanocladus (C. Muell.) Roth.

D. uncinatus (Hedw.) Warnst.; Noguchi, p. 82. Swat State.

Hygroamblystegium Loesk.

H. filicinum (L.) Dix.; Dixon, p. 311. Kagan Valley.

H. fluviatile (Sw.) Loesk.; Noguchi, p. 82. Changla Gali.

Platyhypnidium Fleisch.

P. rusciformis (Neck.) Fleisch.; Noguchi, p. 82. Murree.

BRACHYTHECIACEAE

Brachythecium Bryol. Eur.

B. buchanani (Hook.) Jaegr.; Dixon, p. 311. Kagan Valley.

B. indico-populum Dix.; Dixon, p. 312. Kagan Valley; Babusar Pass.

B. emodi-glareosum Broth.; Dixon, p. 311. Kagan Valley.

B. myrurelliforme Dix.; Stoermer, p. 225. Chitral.

B. velutinum (Hedw.) Br. & Sch.; Stoermer, p. 225. Chitral.

Eurhynchium Bryol. Eur.

E. strigosum (Hoffm.) Bryol. Eur; Brühl, p. 98. Chitral.

Oxyrhygium (Bryol. Eur.) Warnst.

O. rusciforme (Neck.) Warnst.; Dixon, p. 313. Kagan Valley.

Pleuropus Griff.

P. euchloron (Bruch.) Broth.; Dixon, p. 311. Kagan Valley.

FABRONIACEAE

Anacamptodon Brid.

A. splachnoides (Froel.) Brid.; Noguchi, p. 81. Changla Gali.

HYPNACEAE

Homomallium (Schimp.) Loesk.

H. loriforme (Broth.) Broth.; Noguchi, p. 82. Changla Gali; Murree.

H. simlaense (Mitt.) Broth.; Dixon, p. 311. Kagan Valley.

Hypnum Hedw. emend. Fleischer

H. pseudoplumosum Brid.; Brotherus, p. 37. Chitral : Jamabatai.

H. rutabulum L.; Brotherus, p. 37. Chitral : Ziarat.

H. selibrosus Hoffm.; Brotherus, p. 33. Chitral : Mirza.

H. strigosum Hoffm.; Brotherus, p. 33. Chitral : Guger.

Vesicularia C. Muell.

V. reticulata (Doz. & Molk) Broth. Lahore; Jhelum.

LESKEACEAE

Leskeella (Limpr.) Loesk.

L. nervosa (Schwaegr.) Loesk.; Brotherus, p. 32; Noguchi, p. 82. Chitral; Changla Gali; Murree.

———var. *rupestris* Berggr.; Stoermer, p. 224. Chitral.

Lescuraea Bryol. Eur.

L. saxicola (Bryol.) Mol.; Dixon, p. 311. Babusar Pass.

Lindbergia Kindb.

L. duthiei (Broth.) Broth.; Noguchi, p. 81. Changla Gali; Murree.

Pseudoleskea Bryol. Eur.

Ps. filamentosa (Dicks.) Broth.; Noguchi, p. 82. Murree.

Rhegmatozon Brid.

R. polycarpus (Griff.) Mitt.; Noguchi, p. 81. Changla Gali.

PLAGIOTHECIACEAE

Plagiothecium Bryol. Eur.

P. silvaticum (Huds.) Bryol. Eur.; Brühl, p. 100. Punjab.

THUIDIACEAE

Anomodon Hook. & Tayl.

A. minor (Beauv.) Lindb.; Noguchi, p. 82. Murree.

A. viticulosus (L.) Hook. & Tayl.; Noguchi, p. 82. Murree.

Haplocladium C. Muell.

H. subulaceum (Mitt.) Broth.; Noguchi, p. 82. Murree.

X. Order : POLYTRICHALES

POLYTRICHACEAE

Catharinaea Ehrh.

C. obtusula C. Muell.; Brotherus. p. 30; Noguchi, p. 89 as *Atrichium obtusulum* (C. Muell.) Jaeg. Chitral : Bundai; Changla Gali.

C. undulata (L.) Web. & Mohr.; Noguchi, p. 82 as *Atrichium undulatum* (L.) Beauv. Swat State.

———var. *haussknechtii* (Jur. & Milde); Noguchi, p. 82. Murree.

Polytrichum Dill.

P. alpinum L.; Noguchi, p. 82. Changla Gali.

P. juniperinum Willd.; Stoermer, p. 214; Noguchi, p. 82. Chitral; Swat State.

Two new species of *Bupleurum* from West Pakistan

E. NASIR

Gordon College, Rawalpindi.

Eighteen species of *Bupleurum* have so far been recorded from N.W. Himalaya and W. Pakistan. In this paper 2 more species have been described. *Bupleurum kohistanicum* was collected by R.R. Stewart and A.R. Beg above Ushu in Swat at an altitude of about 9000 feet. *Bupleurum hazaricum* was collected by A.R. Beg in September 1956 from the Miranjani top, near Nathia Gali in Hazara district.

I am grateful to Mr M.A. Siddiqi for helping me with the figures and Dr Rimo Bacigalupi for the Latin diagnoses.

***Bupleurum kohistanicum* Nasir, sp. nov**

Plantae erectae ad 50 cm. altae foliis lanceolatis eis inferioribus 8-10 cm. longis 2 cm. latis angustatis 7-9-venatis eis superioribus minoribus involucri bractea unica lineari 5-venata 3 mm. longa vel deficiente radiis 9 vel paucioribus tenuibus 4 cm. longis involucelli bracteolis linearibus 4-5 pedicellis quam floribus 3-4- plo. longioribus fructibus cylindraceis 2-3-vittatis quam pedicellis dimidio longioribus.

Plants erect, 50 cm. tall, few branches. Leaves broadly lanceolate, base narrow, with 7-9 veins, upper half 3-5-veined, apex cuspidate to mucronate; upper leaves smaller. Involucral bract 1, 3 mm. long, linear, 5-veined or none. Rays up to 9, thin, up to 4 cm. in length. Bractlets 4-5, linear, shorter or as long as the flower pedicels, 3-veined. Flowers about 10, petals yellow; pedicels 3-4 times the length of flowers. Fruit cylindrical, half as long as the pedicels; 2-3 vittate; fruit pedicel 4 mm. long.

TYPE LOCALITY. Above Ushu, Swat kohistan, R.R. Stewart & A.R. Beg, 25290 (RAW)

***Bupleurum hazaricum* Nasir, sp. nov.**

Plantae erectae ca. 55 cm. altae ex radice fusiformi foliis basalibus ad 15 cm. longis lanceolatis 5-venatis longipetiolatis petiolis longitudine tertiam partem vel mediam laminarum aequantibus eis medio ac partibus superioribus caulium minoribus sessilibus amplexicaulis basi attamen 25-venatis pedunculis crassis ad 8 cm. longis involucri bracteis duabus inaequalibus ovalibus vel ovatis radiis 2-4 crassis ad 4 cm. longis flores plures atropurpu-

reos aequantibus vel eos excedentibus umbellulis fructiferis magnis fere spheroidis fructibus ellipticis vel oblongis 3.5 mm. longis 2 mm. latis costis prominentibus haud alatis sulci 3-vittatis.

Plants erect, about 55 cm. tall. Root fusiform. 1 or 2 stems from the base; branches few. Basal leaves lanceolate, long petioled, up to 1.5 cm. broad, 15 cm. long; petiole one-third to one-half the length of lamina; veins 5, apex acute; middle and upper cauline leaves sessile, smaller,



A-D. *Bupleurum hazaricum* Nasir. A, Habit sketch, $\times 1/3$; B, Bractlet, $\times 4$; C, Fruit, $\times 3$; D, Transverse view of mature fruit, $\times 10$.

E. *Bupleurum kohistanicum* Nasir. Habit sketch, $\times 1/3$.

amplexicaule, broad at the base with about 25 veins; upper part with 5-7 veins; apex cuspidate. Peduncle stout, up to 8 cm. long. Involucral bracts 2, unequal, oval to ovate, up to 1.5 cm. long, 8 mm. broad; the veins up to 19. Rays 2-4, stout, up to 4 cm. long, angular. Involucels of 5-6 oval to broadly ovate bractlets, 5-7 veined, as long as or longer than the flowers, connate at the base, mucronate, up to 6 mm. long, 4 mm. broad. Flowers

numerous; pedicels as long as or little longer than the flowers; petals and the stylopodia almost black. Fruiting heads full. Fruit elliptic to oblong, up to 3.5 mm. long, 2 mm. broad; ridges prominent, unwinged; the furrows 3-vittate.

TYPE LOCALITY. Miranjani, Hazara Dist., A.R. Beg, 1115 (RAW).

A key to the genera and the species of Umbelliferae of N.W. Himalaya and West Pakistan

E. NASIR

Gordon College, Rawalpindi.

Umbelliferae is a natural family and the members can be readily recognized by their hollow stems, usually compound and much divided leaves with petioles expanded or sheathing at the bases, umbellate inflorescences and schizocarpic fruits splitting into 2 cremocarps. A few genera like *Hydrocotyle*, *Centella* and *Bowlesia* may have non-sheathing leaf bases and the genus *Bupleurum* has entire leaves, but on the whole the morphological characters of the family are fairly constant and similar. These constant characters make the identification of the genera and the species rather difficult. In most cases it is almost impossible to identify the genera and the species unless mature fruits are present. The fruit characters like the shape, the size, the presence or the absence and the number of the resin canals, the presence or the absence of hairs, barbs and bristles, the primary and the secondary ridges, the wings, the shape of the stylopodia and the length of the styles are important.

In Hooker's flora only 35 genera from N.W. Himalaya and W. Pakistan are listed. A number of these are under names which are not in use now. C.B. Clarke in his key in Hooker's flora does not use contrasting characters with the result that it is extremely difficult to identify the different genera. He has not given any key to the species.

In the present paper the writer has listed 45 genera and 92 species from N.W. Himalaya and W. Pakistan. Most of these are found in the temperate regions from 3000 to 9000 feet. A few are alpine. A number of umbellifers from Baluchistan are not very well known and they require more study.

I wish to express my thanks to Dr R.R. Stewart for the help he gave me in the preparation of this paper.

KEY TO THE GENERA

- | | | | | | |
|-------------------|-----|-----|-----|-----|---|
| 1. Umbels simple. | ... | ... | ... | ... | 2 |
| Umbels compound. | ... | ... | ... | ... | 4 |

2. Plants glabrous or pubescent with simple hairs ... 3
Plants stellate pubescent ... **Bowlesia**
3. Leaves finely pubescent. Involucre of 2 orbicular to ovate bracts.
Fruit with 2 reticulated secondary dorsal ridges. Petioles
sheathing ... **Centella**
Leaves sparsely pubescent. Involucre inconspicuous. Fruit without
secondary ridges. Petioles not sheathing **Hydrocotyle**
4. Flower and fruits sessile or subsessile in dense heads or head-like
umbellets ... 5
Flowers and fruits pedicellate or subsessile. Fruit with secondary
ridges prominent or not prominent, winged or not winged, glabrous
or pubescent. Leaves simple or compound ... 6
5. Flowers in head-like irregularly compound few rayed umbellets.
Fruits with uncinat hairs. Leaves not rigid and spi-
nose ... **Sanicula**
Flowers in dense bracteate head. Leaves and bracts rigid and
spinose ... **Eryngium**
6. Leaves simple with entire margins ; narrowly linear to lanceolate or
almost round ... **Bupleurum**
Leaves simple or compound, variously lobed and divided 7
7. Fruit with secondary ridges most prominent. Fruit winged and
equipped with barbs and bristles. Primary ridges slender and
bristly ... 8
Fruit with secondary ridges not prominent. Fruit glabrous to
tomentose or setose (Hairs). Fruit ridges prominent or not promi-
nent. Fruit with or without wings, papillate or tuberculate 10
8. Calyx teeth prominent. Fruit flattened laterally. Seed face
sulcate ... 9
Calyx teeth obsolete. Fruit flattened dorsally. Seed face flat.
Bracts pinnate. Central flower of each umbellet usually
purple ... **Daucus**
9. Fruit oblong, secondary ridges concealed by numerous bristles
occupying the whole interval ... **Torilis**
Fruit linear to oblong, secondary ridges concealed by 1-3 rows of
bristles ... **Caucalis**
10. Fruit with some or all primary ridges conspicuously winged 11
Fruit with ridges more or less prominent but not distinctly
winged ... 21

- | | | | | |
|-----|--|-----|-----|----------------------|
| 11. | Fruit with all ridges conspicuously winged | ... | ... | 12 |
| | Fruit much dorsally compressed; dorsal and intermediate ridges not winged; lateral broadly winged | ... | ... | 16 |
| 12. | Fruit nearly terete; compressed laterally; ridges inflated, spongy and tubercled | ... | ... | <i>Trachydium</i> |
| | Fruit half or nearly terete, somewhat dorsally compressed | ... | ... | 13 |
| 13. | Fruit dorsally compressed; epicarp spongy. Fruit ridges broad, wavy, equal. Flowers yellow. Leaves divided into filiform segments | ... | ... | <i>Prangos</i> |
| | Lateral wings broader than the dorsal and the intermediate | ... | ... | 14 |
| 14. | Dorsal furrows 2-3 vittate. Stem base usually fibrous. | ... | ... | <i>Ligusticum</i> |
| | Dorsal furrows usually 1-vittate | ... | ... | 15 |
| 15. | Bracts linear or absent. Bractlets linear, usually not divided. Stem base usually fibrous | ... | ... | <i>Selinum</i> |
| | Bracts broad, often pinnatifid. Bractlets many, usually broad, white margined | ... | ... | <i>Pleurospermum</i> |
| 16. | Carpels and fruits glabrous | ... | ... | 17 |
| | Carpels and fruits pubescent | ... | ... | 20 |
| 17. | Flowers yellow, often polygamous | ... | ... | 18 |
| | Flowers white | ... | ... | 19 |
| 18. | Leaf segments filiform. Plants annual | ... | ... | <i>Peucedanum</i> |
| | Leaf segments not filiform, leaves pinnate or pinnatifid. Plants perennial | ... | ... | <i>Ferula</i> |
| 19. | Fruit 1 cm. long and 5 mm. broad. 1-vittate | ... | ... | <i>Angelica</i> |
| | Fruit 7 mm. long and 4 mm. broad. Many-vittate. Stem 2 or more cm. thick | ... | ... | <i>Archangelica</i> |
| 20. | Fruit ovate, oblong or obovate, wings broad and thin, 1-vittate. Vittae extending one-half or three-fourths the way to the base of the fruit | ... | ... | <i>Heracleum</i> |
| | Fruit oblong to obovate, wings broad with thickened corky margins; 1-vittate. Vittae large, extending the whole length of the furrows | ... | ... | <i>Ducrosia</i> |
| 21. | Fruit more than thrice as long as broad | ... | ... | 22 |
| | Fruit not more than thrice as long as broad | ... | ... | 26 |
| 22. | Fruit glabrous | ... | ... | <i>Chaerophyllum</i> |
| | Fruit hispid all over the surface or along the margins only | ... | ... | 23 |
| 23. | Fruit with the beak upto 35 mm. long. Beak twice as long as the fruit. Fruit hispid along the margin of the beak | ... | ... | <i>Scandix</i> |
| | Fruit up to 15 mm. long ; hispid all over the surface | ... | ... | 2, |

24. Leaves large with oval to ovate leaflets. Leaflets up to 5 cm. long ; coarsely toothed. Fruit attenuate at the base with adpressed hairs. Style one-and-a-half times as long as the stylopodium *Osmorhiza*
Leaves pinnately divided with small linear to oval segments 25
25. Fruit dark and hispid. Plants up to 8 feet tall *Anthriscus*
Leaves with long grass-like segments. Plants 2-3 feet tall finely pubescent *Pycnocycla*
26. Carpel and fruit densely hairy 27
Fruit glabrous 32
27. Hairs on fruit long. Flowers white to pink. Plants annual *Psammogeton*
Hairs on fruit and carpel short. Flowers white. Plants perennial 28
28. Rays more than 20. Fruit ridges prominent. Fruit cylindrical ; up to 5 mm. long. Leaflets coriaceous ; teeth acute *Seseli*
Rays up to 20. Fruit oval to almost round, up to 3 mm. long ... 29
29. Leaf segments long, filiform. Styles short 30
Leaf segments linear to broad 31
30. Fruit 2-3 mm. long, ovoid. Pedicels hairy. Calyx teeth obsolete *Trachyspermum*
Fruit 5 mm. long, oblong. Pedicels not hairy. Calyx teeth subulate, 1 mm. long *Cuminum*
31. Leaf segments linear to lanceolate. Rays up to 9, thin. Style as long as or longer than the ovary. Bractlets present. Fruit 1.5 mm. long *Eriocycla*
Leaves very variable. Leaf segments lanceolate to ovate. Basal leaves sometimes simple. Fruit ovate, 2 mm. long. Style half as long as the ovary. Bractlets absent *Pimpinella diversifolia*
32. Leaf segments narrowly linear or filiform 33
Leaf segments not filiform or narrowly linear 37
33. Flowers yellow *Foeniculum*
Flowers white 34
34. Roots tuberous 35
Roots not tuberous 36
35. Fruit almost round, 2 mm. long, ridges obscure *Scaligeria*
Fruit cylindrical. 4 mm. long, ridges prominent *Bunium*
36. Plants annual. Fruit globose *Coriandrum*
Plants annual or perennial. Fruit oblong, 5 mm. long ... *Carum*

37. Water or marsh plants or plants growing near water ... 38
 Not marshy or water plants ... 40
38. Fruit ridges not prominent; fruit ovoid. Bracts and bractlets present ... ***Ferula***
 Fruit ridges prominent and corky ... 39
39. Calyx teeth not present. Rays upto 12. Fruit ridges very broad. Leaflets lanceolate to oval ... ***Sium***
 Calyx teeth prominent. Rays upto 20. Leaves 1-2 pinnate. Leaflets oval to ovate ... ***Oenanthe***
40. Bractlets divided at the top. Fruit ovoid ; 3-5 vittate; ridges prominent, corky, dorsal and the intermediate approximated. An alpine plant ... ***Schulzia***
 Bractlets absent or not divided when present ... 41
41. Bractlets absent ... 42
 Bractlets present ... 43
42. Umbels leaf opposed. Fruit with prominent ridges; 1—vittate. Leaves somewhat fleshy ... ***Apium***
 Umbels terminal and lateral. Fruit ridges obscure, vittae none ... ***Aegopodium***
43. Leaves pinnate with small linear to lanceolate segments. Fruit oblong-ovate. Bract 1, linear or absent. Flowers white to purplish ... ***Vicatia***
 Leaf segments large, narrowly lanceolate to ovate ... 44
44. Leaf segments narrowly lanceolate. Rays many, dense and stiff. Bracts divided ... ***Ammi***
 Leaf segments oval to ovate. Rays not dense. Bracts simple or absent ... 45
45. Fruit ridges thin or obscure. 2-3 vittate ... ***Pimpinella***
 Fruit ridges prominent, wavy, striate between the ridges. Vittae none ... ***Conium***

1. AEGOPODIUM

Aegopodium alpestre Ledeb. This was described by Dunn as a new species. He called it *Pimpinella kashmirica*. Found in Kashmir, Swat, Chitral, Gilgit Agency, from 7000 to 12000 ft.

2. AMMI

KEY TO THE SPECIES

Leaf segments linear *A. visnaga*

Leaf segments lanceolate *A. huntii*

Ammi visnaga Lam. Cultivated. Fruits used for the extraction of Khellin and visnaga. Peshawar.

Ammi huntii Wats. Lahore, Abbottabad.

3. ANGELICA

Angelica glauca Edgew. A tall plant. Grows in Kashmir, Swat, Hazara.

4. ANTHRISCUS

Anthriscus nemorosa Spreng. A tall plant. Kashmir, Lahul, Gilgit, Swat, from 8000 to 12000 ft.

A. nemorosa var. *glabriusculus* Nasir, var. nov. Fructus glabriusculus. Fruit almost glabrous. Specimens from Serimang, Bagh Tehsil, are quite glabrous. Type locality Kamri, Kashmir, Stewart and Nasir 22724 (RAW & UC).

5. APIUM

Apium graveolens L. Wild celery. Peshawar, Swat, Gilgit, Kashmir.

6. ARCHANGELICA

Archangelica officinalis Hoff. var. *himalaica* C. B. C. A tall plant. Kashmir, Gilgit Agency, Deosai plains.

7. BERULA

Berula erecta (Huds.) Cdv. (Syn. *B. angustifolia* Koch.). Grows in wet places in Kashmir, Chitral, Peshawar, Baluchistan.

8. BOWLESIA

Bowlesia asiatica Nasir. Grows in damp sheltered places in Rawalpindi.

9. BUNIUM

Bunium persicum Boiss. Resembles *Scaligeria* but can be recognized by its cylindrical fruit. Gilgit, Swat, Chitral, Hazara, Kashmir. 6000 to 10000 ft.

10. BUPLEURUM

KEY TO THE SPECIES

1. Umbels compound, multiradiate 2
 Umbels compound but uniradiate. Branching dichotomous;
 branches numerous and slender. Leaves mostly small, needle-
 like ***B. subuniflorum***
2. Leaves perfoliate ***B. croceum***
 Leaves petioled to amplexicaule 3
3. Basal and cauline leaves long petioled, oval to broadly
 oval ***B. lanceolata***
 Basal leaves long petioled, sessile or subsessile, narrow, linear to
 oval 4
4. Cauline leaves sessile to subsessile, lanceolate, oval or oblong, up to
 15 cm. long, the upper with more than 9 veins. Bractlets usually
 broadly lanceolate to ovate with (3-) 5-9 veins ... 5
 Cauline leaves sessile, narrowly linear to lanceolate, smaller leaves
 sometimes oval to oblong. Leaves up to 16 cm. long; upper with
 3-11 (usually 5-9) veins. Bractlets linear to lanceolate with 3 (-5)
 veins 15
5. Leaves slightly amplexicaule to broadly lanceolate, thin with distinct
 venation 6
 Leaves amplexicaule, lanceolate to ovate, thick or thin with obscure
 or distinct venation. Fruit ridges winged or unwinged ... 7
6. Flower and fruit pedicels short ***B. candollei***
 Flower and fruit pedicels long ***B. kohistanicum***
7. Plants xerophytic. Leaves slightly amplexicaule, venation obscure.
 Bract and/or bractlets minute or absent ***B. swatianum***
 Plants mesophytic. Leaves amplexicaule, thin, venation distinct.
 Bractlets conspicuous 8
8. Bases of upper leaves broad, cordate with up to 45 veins. Bractlet
 not foliaceous. Flowers yellow. Fruit ridges thick or
 winged 9
 Bases of upper leaves not cordate, with up to 23 veins. Bractlets
 foliaceous or not. Flowers dark purple, occasionally yellow.
 Fruit ridges winged or unwinged 10
9. Bases of upper leaves deeply cordate, apices obtuse or acute.
 Fruit disc light yellow to light brown; ridges slightly
 winged ***B. jucundum***

- Bases of upper leaves shallowly cordate or amplexicaule, apices usually acuminate. Fruit disc light to dark brown; ridges very broadly winged ***B. thomsonii***
10. Bractlets not foliaceous. Fruit ridges prominent but winged 11
 Bractlets usually foliaceous. Fruit ridges winged ... 12
11. Basal leaves not petioled. Fruiting umbellet not large ***B. constancei***
 Basal leaves long petioled. Fruiting umbellet large forming a globose head ***B. hazaricum***
12. Plants up to 1 m. tall, erect or decumbent, upper leaves with up to 25 veins. Flowers dark purple except in var. *clarkeanum* ***B. longicaule***
 Plants up to 35 cm. tall, decumbent. Upper leaves with up to 15 veins. Flowers not purple. Fruit disc usually dark brown ***B. dalhousieanum***
13. Plants perennial. Stems erect. Leaves linear to lanceolate. Furrows 3-vittate ***B. falcatum***
 Plants annual or perennial. Stems erect or decumbent. Leaves narrowly linear to oblong. Furrows 1-3-vittate ... 14
14. Leaves linear to oblong. Fruit ridges winged or unwinged. Furrows 1-vittate 15
 Leaves narrowly linear to lanceolate. Fruit ridges unwinged. Furrows 3-vittate 16
15. Stems erect or decumbent. Leaves linear to oblong. Rays filiform. Flowers subsessile. Fruit ridges unwinged ... ***B. tenue***
 Stems erect. Leaves linear, about 2 cm. long. Rays stout. Flowers pedicellate. Fruit ridges winged ***B. stewartianum***
16. Leaves linear to broadly linear, up to 4 cm. long, apex long-acute. Flowers subsessile ***B. maddenii***
 Leaves (cauline) few, thick, narrowly linear to lanceolate, up to 6 cm. long, apex obtuse to acute. Flowers subsessile to pedicellate. Plants xerophytic 17
17. Basal leaves long petioled, the cauline linear. Rays 3-5, up to 1.5 cm. long ***B. gilesii***
 Basal leaves sessile, linear, the cauline narrowly linear to lanceolate. Rays 2-7, 1-5 cm. long 18
18. Plants erect; stem usually solitary from base. Leaves sub-involute and grooved ***B. canaliculatum***
 Plants decumbent; main stem very short with many branches from the base. Leaves plane, neither involute nor grooved ... 19

19. Rays stout, up to 1 cm. long *B. aitchisonii*
 Rays slender, up to 5 cm. long *B. gracillimum*
Bupleurum aitchisonii Wolff. Reported from Kurram Valley only.
 An alpine.

B. aitchisonii f. *atro-violacea* O.E.S. has dark purple flowers. Kashmir. An alpine plant.

Bupleurum canaliculatum Diels. Rattu, Ladak.

Bupleurum candollei Wall. Murree hills, Kishan Ganga Valley, Simla.

Bupleurum constancei Nasir. Grows in Swat.

Bupleurum croceum Fenzl. Collected from Kotli, Rawalpindi and N. W. F. P. Specimens from Hilan Khurd, near Kotli almost approach *B. rotundifolium*.

Bupleurum dalhousieanum (C.B.C.) K-Pol. Reported from Dalhousie.

Bupleurum falcatum L.

KEY TO THE VARIETIES

1. Plants stout; leaves linear to lanceolate 2
 Plants slender; leaves narrowly linear *B. falcatum* var. *linearifolium*

2. Lower leaves long and linear, upper lanceolate; rays 4-8; fruit ridges thin *B. falcatum* var. *marginatum*

Lower leaves shorter and lanceolate, upper falcate and abruptly acute; rays 7-10; fruit ridges thick and prominent *B. falcatum* var. *hoffmeisteri*

Bupleurum falcatum var. *marginatum* (Wall) C.B.C. Kashmir, Lahul, Ladak, Baltistan, Hazara, Poonch. 7000-12000 feet.

Bupleurum falcatum var. *hoffmeisteri* (Kl.) C.B.C. Kashmir, Swat.

Bupleurum falcatum var. *linearifolium* (DC) Boiss. Kashmir, Swat.

Bupleurum gilesii Wolff. It has long petioled oval basal leaves. Chitral.

Bupleurum gracillimum Kl. A decumbent plant with numerous slender stems from the base. Baltistan, Ladak, Lahul.

Bupleurum hazaricum Nasir. Collected from the type locality, Miranjani, only at 10000 feet.

Bupleurum jucundum Kurz. Kashmir, Kangra Dist., Baltistan, Gilgit Agency, Changla Gali. Grows from 6000 to 11000 feet.

Var. *cachemirica* C.B.C. has no involucre bracts. Lahul, Srinagar.

Bupleurum kohistanicum Nasir. Collected above Ushu, Swat at 8000-9000 ft.

Bupleurum lanceolatum Wall. Kashmir, Swat, Murree hills. Common at 7000-8000 ft.

Bupleurum longicaule Wall.

KEY TO THE VARIETIES

1. Bractlets large; flowers dark purple 2
 Bractlets small (or lacking), never foliaceous; flowers
 yellow *B. l.* var. *clarkeanum*
2. Plants erect, stem usually solitary; bractlets twice as long as the
 flowering umbellet. *B. l.* var. *himalayense*

Plants erect or decumbent, more than one stem from base;
 bractlets as long as or a little longer than the flowering umbel-
 lets *B. l.* var. *ramosum*

Bupleurum longicaule var. *himalayense* (Kl.) C.B.C. Kashmir, Baltis-
 tan, Gilgit Agency, Simla, Kunawar. From 7000 to 12000 feet.

Bupleurum longicaule var. *ramosum* Nasir. An alpine and a smaller
 plant. Kashmir.

Bupleurum longicaule var. *clarkeanum* Wolff. This is described
 under *B. diversifolium* in Hooker's flora. It resembles *B. thomsonii*
 but the lower leaves are more linear and the upper have amplexi-
 caule and inflated leaf bases. Collected from Sonamarg, Kashmir.

Bupleurum maddenii C. B. C. Resembles *B. tenue*. Reported from
 Mussoorie and Simla.

Bupleurum stewartianum Nasir. Very xerophytic with small leaves.
 Collected only from the type locality. Ilam in Swat.

Bupleurum subuniflorum Boiss. This is described under *B. setaceum*
 in Hooker's flora. Swat, Kishen Ganga Valley, Jhelum Valley road,
 Poonch, Kashmir.

Bupleurum swatianum Nasir. Very xerophytic. Kalam and Ushu
 in Swat.

Bupleurum tenue Buch. Ham. Mussoorie, Simla, Kulu, Kashmir,
 Murree Hills, Swat.

Bupleurum thomsonii C. B. C. Kashmir, Gilgit Agency, Lahul.
 9000-12000 feet.

11. CARUM

KEY TO THE SPECIES

- Fruit glabrous *C. carui*
 Fruit verruculose *C. copticum*

Carum carui L. This is widely distributed from 7000 to 14000 ft.

Carum copticum Benth. (Syn. *C. aromaticum* Druce). Ajwain.
Cultivated. Plains to 8000 ft.

12. CAUCALIS

KEY TO THE SPECIES

Flowers white; leaf segments narrow *C. stocksiana*
Flowers pinkish; leaf segments broad *C. latifolia*
Caucalis stocksiana Boiss. Grows from foot hills to 8000 ft.
Caucalis latifolia L. Kashmir, Swat, Chitral, Kotli, Kishen Ganga
Valley.

13. CENTELLA

Centella asiatica (L.) Urb. Prostrate, growing in damp soil.
Plains to 8000 ft.

14. CHAEROPHYLLUM

KEY TO THE SPECIES

Leaf segments entire, linear to lanceolate; roots tuber-
ous *C. capnoides*
Leaflets closely regularly serrate *C. acuminatum*
Stem and leaves glabrous or sparingly hairy *C. reflexum*
Stem and leaves very hairy *C. villosum*
Chaerophyllum acuminatum Lindl. Resembles *C. villosum* except for
the leaves. Kashmir, Lahul, Kangra Dist., Kagan, Gilgit. 3000 to
11000 feet.
Chaerophyllum cachemiricum var. *dissecta* C. B. C. with finely cut
leaves is reported from Kashmir. There is one poor specimen in
the G.C. Herbarium.
Chaerophyllum capnoides Benth. Leaves look like *Scaligeria aitchi-*
sonii. Shin Nullah, Kulu; also reported from Kishtwar and Chitral.
Chaerophyllum reflexum Lindl. Kashmir, Kulu, Murree Hills, Swat.
4000-10000 ft.
Chaerophyllum villosum Wall. Kashmir, Lahul, Swat, Poonch,
Kagan, Murree Hill. 8000-12000 feet.

15. CONIUM

Conium maculatum L. Hemlock. Poisonous. Kashmir, Jhika Gali,
Abbottabad.

16. CORIANDRUM

Coriandrum sativum L. Dhania. Cultivated.

17. DAUCUS

Daucus carota L. Common. Cultivated.

18. CUMINUM

Cuminum cyminum L. Cultivated. Baluchistan.

19. DUCROSIA

KEY TO THE SPECIES

- Pinnae ovate, trilobed *D. ovatiloba*
 Pinnae linear to lanceolate *D. anethifolia*
Ducrosia anethifolia Boiss. Swat, Baluchistan, 3000-4000 ft. *Zozimia*
absinthifolia DC. (*Z. orientalis* Hoff.) probably belongs to this
 group.
Ducrosia ovatiloba Dunn et Williams. Chitral, 4000-5000 ft.

20. ERIOCYCLA

KEY TO THE SPECIES

1. Plants up to 20 cm. tall; bractlets lanceolate *E. caespitosa*
 Plants up to 40 cm. tall; bractlets linear *E. thomsonii*
 Plants up to 1 m. tall; upper part almost leafless 2
 2. Leaf segments ovate *E. nuda*
 Leaf segments linear, several branches from the base *E. stewartii*
Eriocyclus caespitosus (Edgew.) Wolff (Syn. *Pimpinella caespitosa*
 Edgew.) Grows in Simla district.
Eriocyclus nuda Lindl. Kunawar, 9000-10,000 ft.
Eriocyclus stewartii (Dunn) Wolff. Common. Grows in dry places
 in Hazara, Swat, Poonch, Salt Range, Rawalpindi Division.
Eriocyclus thomsonii (C. B. C.) Wolff. Grows in Lahul from 14,000
 to 15,000 feet.

21. ERYNGIUM

Eryngium coeruleum Bieb. An erect 2-3 ft. spiny plant with bluish
 flowers. Common up to 4000 ft.

22. FERULA

KEY TO THE SPECIES

1. Plants large, up to 2.4 m. tall 2
 Plants small *F. stewartianum*
 2. Fruit 18 x 8 mm. *F. jaeschkeana*
 Fruit 8 x 5 mm. *F. narthex*

Ferula jaeschkeana Vatke. Kashmir, Gilgit Agency.

Ferula narthex Boiss. Baltistan, Astor.

Ferula stewartiana O. E. S. Grows in limestone rocks on the mountain above Hasan Abdal.

23. FOENICULUM

Foeniculum vulgare Gaertn. Fennel. Commonly cultivated.

24. HERACLEUM

KEY TO THE SPECIES

- | | | | | | | |
|----|---|-----|-----|-----|------------------------|---|
| 1. | Leaf segments 1-2 cm. | ... | ... | ... | ... | 2 |
| | Leaf segments larger | ... | ... | ... | ... | 3 |
| 2. | Leaf segments oval-ovate, leaves pinnate, bipinnate | | | | <i>H. thomsonii</i> | |
| | Leaf segments lanceolate to oval, margin entire | | | | <i>H. cachemiricum</i> | |
| 3. | Rays 4-8; styles very long | ... | ... | ... | <i>H. brunonis</i> | |
| | Rays more than 10 | ... | ... | ... | ... | 4 |
| 4. | Rays 20-30; large plants | ... | ... | ... | <i>H. candicans</i> | |
| | Rays 10-20 | ... | ... | ... | ... | 5 |
| 5. | Rays up to 15; plants very hairy, fruit 1 cm. | ... | | | <i>H. canescens</i> | |
| | Rays about 20; few leaves in the upper part, fruits about 7-8 mm. | | | | <i>H. pinnatum</i> | |

Heracleum candicans Wall. A large plant. Kashmir, Baltistan, Kagan, Gilgit, Parachinar, Murree Hills.

Heracleum canescens Lindl. This has a large fruit. Mussoorie, Murree, Abbottabad from 5000 to 9000 feet.

Heracleum pinnatum C. B. C. Found in Kashmir, Gilgit, Baltistan, 9000-10000 ft.

Heracleum thomsonii C. B. C. Leaflets pubescent. Found in Gilgit Agency and Baltistan from 9000 to 11000 feet.

H. thomsonii var. *glabrior* C. B. C. Leaflets glabrous. Kashmir, Baltistan, Gilgit, Swat, Chitral, Baluchistan. 8000-10000 feet.

25. HYDROCOTYLE

KEY TO THE SPECIES

- | | | | |
|---------------------------------------|------------|--------------------|------------------------|
| Leaves about 1-2 cm. in diameter | ... | ... | <i>H. rotundifolia</i> |
| Leaves 25-6 cm. in diameter | ... | ... | <i>H. javanica</i> |
| <i>Hydrocotyle javanica</i> Thunb. | Prostrate. | Mussoorie, Chamba. | |
| <i>Hydrocotyle rotundifolia</i> Roxb. | Prostrate. | Plains to 4000 ft. | |

26. LIGUSTICUM

Ligusticum thomsonii C. B. C. It looks like a *Selinum* and is 2-3 ft. tall. Kashmir, Chitral, 7000-10000 ft.

L. thomsonii var. *evolutior* C. B. C. is a larger plant with larger leaf segments.

27. OENANTHE

Oenanthe stolonifera Wall. Grows in wet places. Plains to 5000 ft.

28. OSMORHIZA

Osmorhiza aristata (Thunb.) Yabe. var. *laxa* Royle. This is under *C. claytoni* in Hooker's flora. Grows in shady places in Kashmir from 6000 to 8000 ft.

29. PEUCEDANUM

Peucedanum graveolens (L.) Benth. Cultivated. Vern. Soe.

30. PIMPINELLA

KEY TO THE SPECIES

Flower and fruit pedicels long and filiform; fruit subglobose, glabrous *P. acuminata*

Flower and fruit pedicels not long; fruit pubescent or pectinate *P. diversifolia*

Pimpinella acuminata C. B. C. Kashmir, Lahul, Mussoorie, Hazara, Murree Hills. Common in rich forests from 5000 to 9000 ft.

Pimpinella diversifolia DC. Kashmir, Chamba State, Swat, Gilgit, Chitral, Kagan, Murree Hills. Common from 5000 to 9000 ft. The fruits of plants from Changla Gali are not hairy but pectinate.

Pimpinella hazariensis Wolff has been reported from Kund, Hazara.

31. PLEUROSPERMUM

KEY TO THE SPECIES

1. Bractlets divided 2

Bractlets not divided 3

2. Bractlets large, leaf-like; umbellets large ... *P. govanianum*

Bractlets and umbellets smaller; umbel arising from the base of the short stem *P. lindleyanum*

3. Bractlets oval to ovate 4

Bractlets linear to lanceolate 5

4. Stem up to 1 cm. thick; leaves pinnate; leaflets oval to ovate; rays up to 12 cm. long *P. candollii*

Stem up to 3 mm. thick; leaves 3-4 pinnate, segments linear except in *f. latisectum*; rays up to 4 cm. long *P. densiflorum*

5. Plants small; bractlets linear; outer flowers pinkish; leaves and umbels radical; fruit smooth *P. hookeri*

Plants tall; bractlets lanceolate; flowers white; fruit epicarp lax *P. stylosum*

Pleurospermum candollii (Wall) Benth. An alpine. A large handsome plant with large bractlets and leaves. Kashmir, Kagan, Poonch, Gilgit, Lahul.

Pleurospermum densiflorum Benth. An alpine. Kashmir, Lahul, Baltistan.

f. latisectum O. E. S. from Mt. Apharwat has broad leaf segments.

Pleurospermum govanianum (DC) Benth. = *P. stellatum* Benth. An alpine plant. Kashmir, Kulu, 1 specimen from Changla Gali.

Pleurospermum hookeri C. B. C. An alpine with pinkish flowers. Ladak, Baltistan, Deosai plains.

Pleurospermum lindleyanum (Kl.) Diels. An alpine. Kashmir, Kagan, Swat, Gilgit Agency, Ladak, Lahul.

Pleurospermum stylosum C. B. C. A tall plant with large bipinnate leaves; pinnae pinnatifid to pinnatisect. Kashmir, Lahul, Gilgit, Swat, Poonch, Mokshpuri near Dunga Gali. 8000-12000 feet.

32. PRANGOS

Prangos pabularia Lindl. A tall plant from 5000 to 9000 feet. Grows in Gilgit Agency, Swat, Chitral, Baltistan.

33. PSAMMOGETON

KEY TO THE SPECIES

Leaves glabrous or sparingly pubescent *P. biternatum*

Leaves densely pubescent *P. canescens*

Psammogeton biternatum Edgew. A common plant in the plains with white to pinkish flowers.

Psammogeton canescens (DC) Vatke. A more hairy plant. Grows in the North-West Frontier and Baluchistan.

34. PYCNOCYCLA

Pycnocycla glauca Lindl. Simla and Kulu districts at about 3000 ft.

35. SANICULA

Sanicula elata Ham. A common forest species growing from 7000 to 9000 feet.

36. SCALIGERIA

KEY TO THE SPECIES

1. Plants about 1 m. tall; much branched; roots oblong-napi-form *S. meifolia*

- Plants less than 1 m. tall; roots globose 2
2. Smaller plant; hardly any basal and few cauline leaves at the fruiting stage; roots up to 1 cm. *S. indica*
- Larger plant; leaves many, leaf segment linear; roots up to 1.5 cm. *S. aitchisonii*
- Scaligeria aitchisonii* Wolff. Chitral, Dir, Swat, Kagan, Hazara, Poonch, Hasan Abdal, Margalla. Plains to 6000 feet.
- Scaligeria indica* Wolff. Swat, 7000-9000 feet.
- Scaligeria meifolia* Fenzl. Chitral, 7000-8000 feet.

37. SCANDIX

KEY TO THE SPECIES

- Bractlets broad with ciliate margins *S. pecten-veneris*
- Bractlets divided into filiform segments *S. pinnatifida*
- Scandix pecten-veneris* L. var. *brevirostris* Boiss. This is common from plains to 7000 feet in spring.
- Scandix pinnatifida* Vent. This is a smaller plant. Quetta.

38. SCHULZIA

- Schulzia dissecta* (CBC) Norman, (*Ligusticum baltistanicum* Wolff.)
- An alpine plant. Kashmir, Baltistan, Deosai, Kulu. 11000-15000 feet.

39. SELINUM

KEY TO THE SPECIES

1. Bractlets pinnate *S. vaginatum*
- Bractlets not pinnate 2
2. Bractlets not white margined; stem base not fibrous. *S. papyraceum*
- Bractlets white margined; stem base fibrous 3
3. All fruit ridges distinctly subequally winged. A fairly large plant *S. candollii*
- The dorsal and the intermediate ridges subulate and approximated *S. tenuifolium*
- Selinum candollii* D. C. Sonamarg in Kashmir and Lahul.
- Selinum papyraceum* C. B. C. This grows in Kashmir, Ladak, Swat, Baltistan, Gilgit Agency from 8000 to 12000 feet.
- Selinum tenuifolium* Wall. Kashmir, Lahul, Kulu Valley, Swat, Chitral, Poonch, Murree Hills. Variety *elata* has winged dorsal ridges and larger fruits.
- Selinum vaginatum* C. B. C. Grows in Kashmir, Ladak, Baltistan, Swat, Astor Valley, Gilgit Agency, Poonch from 7000 to 12000 feet.

40. SESELI

Seseli libanotis (L.) Koch. A 2-4 feet tall plant, frequently growing on rocks. Kashmir, Swat, Chitral, Gilgit, Kagan. 6000 to 12000 feet.

41. SIUM

Sium latijugam C. B. C. Common near irrigation ditches. Kulu, Lahul, Kashmir, Gilgit, Swat, Baltistan.

42. TRACHYDIUM

Trachydium roylei Lindl. A small alpine plant with many much divided radical leaves and a well developed thick tap root. Kashmir, Kagan, Swat, Baltistan.

43. TRACHYSPERMUM

Trachyspermum falconeri (CBC) Wolff. A tall plant with filiform leaf segments. Mussoorie, 6000 to 7000 feet.

44. TORILIS**KEY TO THE SPECIES**

Bristles long, slender, straight and shining ... *T. leptophylla*

Bristles shorter, thicker, curved, almost hooked ... *T. japonicus*

Torilis leptophylla (L.) Reich. An annual weed growing from plains to 5000 feet.

Torilis japonicus D. C. = *T. anthriscus* (L.) Gmel. A taller plant growing from 4000 to 8000 feet.

45. VICATIA**KEY TO THE SPECIES**

Basal leaf segments linear ; fruit ovoid, narrowed upwards, 4 mm.

long *V. coniifolia*

Basal leaf segments elliptic ; fruit ovoid, not narrowed upwards, 2

mm. long *V. wolffiana*

Vicatia coniifolia D. C. Kashmir, Kulu, Gilgit, Swat, Poonch, Hazara. 6000 to 12000 feet.

Vicatia wolffiana (W & F) Norman, (*Pimpinella saxifraga* var. *dissectifolia* Ladak, Gilgit, Baltistan. 10000 to 14000 feet.

The skeleton of *Rita rita* (Hamilton)

(Teleostei, Siluridae)

TAHIR AHMAD HASHMI, M.Sc.

Biological Laboratories, Government College, Lahore.

CONTENTS

I.	Introduction	...	...	...	74
II.	Technique	...	...	..	74
III.	The skeleton				
1.	The skull	...	...	...	75
i.	General characteristics	...	...	...	75
ii.	The skull proper	...	...	...	77
a.	Nasal region	...	...	...	78
b.	Orbito-temporal region	...	...	...	81
c.	Auditory region	...	...	...	84
d.	Occipital region	...	...	...	88
iii.	The visceral skeleton	...	...	...	91
a.	Upper jaw	...	...	...	92
b.	Lower jaw	...	...	...	94
c.	Hyoid arch	...	...	...	95
d.	Branchial arches	...	...	...	98
e.	Gill covers	...	...	...	99
2.	The vertebral column	...	...	...	100
3.	The ribs	...	...	...	107
4.	The girdles	...	...	...	107
i.	Pectoral girdle	...	...	...	107
ii.	Pelvic girdle	...	...	...	110
5.	The fins	...	...	...	111
i.	Pectoral fin	...	...	...	111
ii.	Pelvic fin	...	...	...	113
iii.	Median fins	...	...	...	113
a.	Dorsal fin	...	...	...	113
b.	Anal fin	...	...	...	114
c.	Caudal fin	...	...	...	115
IV.	Conclusions and discussion	...	...	...	116
V.	List of abbreviations	...	...	...	119
VI.	References	...	...	...	120

I. INTRODUCTION

The Khagga, *Rita rita* (Ham.), is a freshwater catfish found abundantly in the rivers of West Pakistan, and dissected as a type of bony fishes in the Panjab University. It is unfortunate that no suitable and authentic account of the anatomy of this fish is available in literature. This is particularly true of its skeleton which, being specialized and reduced, differs considerably from that of the types commonly described in the text-books of Zoology.

Dr Hamid Khan Bhatti, Professor of Zoology in the F. C. College, Lahore, made a detailed study of the skeleton of this fish about 40 years ago when he was a student in these Laboratories. However, his dissertation was never published, and is not available now even for reference. The present study is an attempt at meeting the need for a detailed and accurate description of the skeleton of *Rita rita* and I hope that this work will serve as a nucleus for a Memoir on this type.

I take this opportunity of expressing my indebtedness to Dr Ahsanul Islam at whose suggestion I took up this work and who helped me with his criticism and advice.

II. TECHNIQUE

Articulated skeletons of *Rita rita* were prepared from specimens preserved in 5% Formaldehyde. The bones were cleared of much of the musculature and boiled for some time in a 0.5% aqueous solution of caustic potash for softening the remaining muscles and tendons which were removed very carefully. The skull was disarticulated from the vertebral column and pectoral girdle, and the brain removed through the foramen magnum, interfrontal fenestra and the optic foramina. The skeleton was then bleached in Ammonia, cleared in Hydrogen peroxide and dried in shade. The disarticulated parts were set in position with the help of Seccotine which is a very good adhesive for bones.

Disarticulated skeletons were prepared by boiling fresh specimens of *Rita rita* in tap water for about two hours, then cleaning all the bones with a stiff brush, and finally boiling them in a weak solution of caustic potash.

This method, however, is not very suitable for the fins. For preparing the skeletons of fins, their proximal ends were dipped in boiling water for about 10-15 minutes and cleared of flesh and fatty tissue. They were then put in a cage of wire gauze and left to be cleared completely by small red ants.

The branches of the lateral line canal system, which usually provide reliable evidence regarding the homologies of bones, were dissected out first in a skull which had been decalcified in Jenkin's decalcifying fixative, and then in a fresh specimen. These dissections gave a clue to the location of the lateral line canal in dried and disarticulated bones of the skull.

III. THE SKELETON

The skeleton of *Rita rita* is built on the typical siluroid plan as described by Jordan (1905), Goodrich (1909), and others. In the adult fish the skeleton is thoroughly ossified, but in smaller (younger?) specimens parts of the cranium are still cartilaginous.

In the course of the present study specimens of different ages ranging in size from 9 cm. to 52 cm. were examined for their skeleton. It was observed that even in the youngest specimen examined, ossification of skeleton had gone a considerable way. The proportions of the major divisions of the skeleton remained almost unaltered despite a five-fold increase in the general size of the body.

For the purposes of description, the following regions may be distinguished in the skeleton of *Rita rita* :

- (a) the skull, including the visceral arch derivatives;
- (b) the vertebral column including the Weberian ossicles and ribs;
- (c) the girdles, pectoral and pelvic;
- (d) the paired fins, pectoral and pelvic;
- (e) the median fins, anterior dorsal, caudal and anal.

1. THE SKULL

(i) GENERAL CHARACTERISTICS

The skull of *Rita rita* is very well-ossified in the adult specimens and is composed of a large number of both replacing and investing bones. As in all vertebrates, it is possible to resolve the skull of *Rita rita* into three components :

- (i) the cranium, enclosing and protecting the brain;
- (ii) the sense-capsules; and
- (iii) the derivatives of the visceral arches.

In the adult skull, the sense-capsules (olfactory and auditory) are very intimately associated with the cranium to form, what may be called, the skull proper. The derivatives of the visceral arches are only loosely attached to it.

The skull proper is very small and narrow, but the hyomandibular and the opercular series are attached to it in such a way that they make the head appear very wide and expanded. The brain case is much shorter than it looks in a dorsal view of the skull and its apparent great length is due to a backward extension of the supraoccipital bone. The skull is sharply depressed in the anterior region.

The first few vertebrae are fused together and are very firmly attached to the skull. When this vertebral complex is detached, the base of the cranium presents a centrum-like appearance, suggesting that a vertebra had fused with the skull. In the anterior part of the cranium, there is a long, slit-like opening in the median line. It may be called the interfrontal fenestra (Fig. 1, *I. Fr. Fn.*). The extent of the fenestra is very variable, but in general it is relatively longer in younger specimens. The nasal fossae are situated at the anterior end, on either side of the mesethmoid just behind the premaxilla.

In the side view, the skull presents a big gap between the cranium and the suspensorium (hyomandibular etc.). This gap serves for the passage of muscles and the V and VII cranial nerves. When the suspensorium and operculum are removed, the cranium is seen to be a long narrow structure, apparently very wide in the posterior region but narrower in the anterior region where it forms a tunnel for the passage of the olfactory tracts. The width of the posterior region is due to the auditory capsules which have fused with the cranium. Just in front of the wide posterior portion, each side wall of the cranium is perforated by a pair of foramina: the foramen for the optic nerve lying in front, and that for trigeminal nerve lying behind. The two foramina are separated by the pleurosphenoid. On the ventral side the wide portion of the cranium is perforated by three foramina: one perforating the pterotic and two perforating the exoccipital. Posteriorly, this region is perforated by the foramen magnum which is bounded by the exoccipitals. Beneath the foramen magnum lies the external opening of the cavum sinus imparis. The skull of *Rita rita* is platytrabic as the brain cavity extends almost to the region of the olfactory capsules. The suspension of the jaws is methyostylic. *

There are two bony capsules for the sense organs, viz., the auditory and the olfactory. The eyeball is enclosed in a thin cartilaginous capsule formed mainly by the sclerotic. In a sagittal section, the cranial cavity

*The term methyostylic was introduced by Gregory (1904) to express the distinction between the suspensorial hyoid arch skeleton in Selachii and Teleostomi. The term *hyostylic* used formerly to describe the type of jaw suspension in both these groups, is now confined to the Selachii.

is seen to pass forwards insensibly into the passage for the olfactory tract, there being no hard and fast line between the two regions.

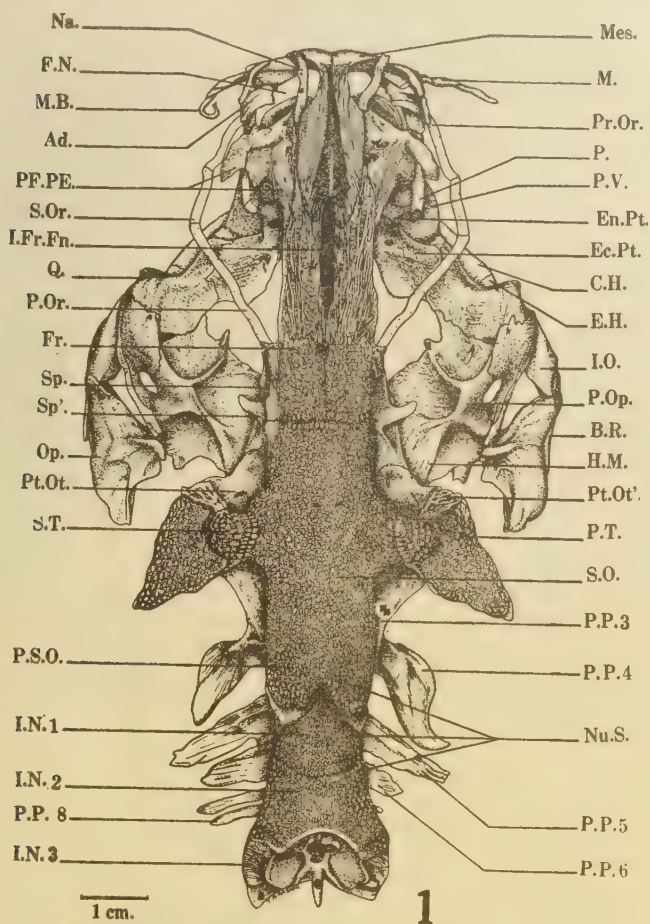


Fig. 1. Dorsal view of the skull and related bones.

(ii) THE SKULL PROPER

For convenience of description, the following regions may be distinguished in the skull proper :

- (a) the nasal or ethmoidal region;
- (b) the orbito-temporal region;

- (c) the auditory or otic region; and
- (d) the occipital region.

A. NASAL REGION

The nasal region includes three investing bones, viz., the nasal, adnasal and prevomer, and two replacing bones, viz., the mesethmoid and the composite prefrontal-cum-parethmoid.

Mesethmoid. The mesethmoid (Figs. 1, 2, 3, & 6, *Mes.*) is a T-shaped median bone, situated at the anterior extremity, between the olfactory capsules. It is best seen in the dorsal view. Its shape and position suggest very strongly that as in *Amiurus* (Kindred, 1919; de Beer, 1937), the mesethmoid is a compound bone formed by the fusion of supraethmoid and median ethmoid. When disarticulated, its longitudinal portion is seen (Fig. 6) to bifurcate in the posterior region into a larger dorsal and a smaller ventral limb or prong. The dorsal limb represents the supraethmoid while the ventral limb signifies the median ethmoid. The horizontal bar of the T-shaped mesethmoid articulates with the premaxillae (Fig. 3, *P. M.*) on the ventral side. A little posteriorly, the ventral or median ethmoid part articulates with the prevomer (*P. V.*) in the mid-ventral line, and is also joined suturally with the

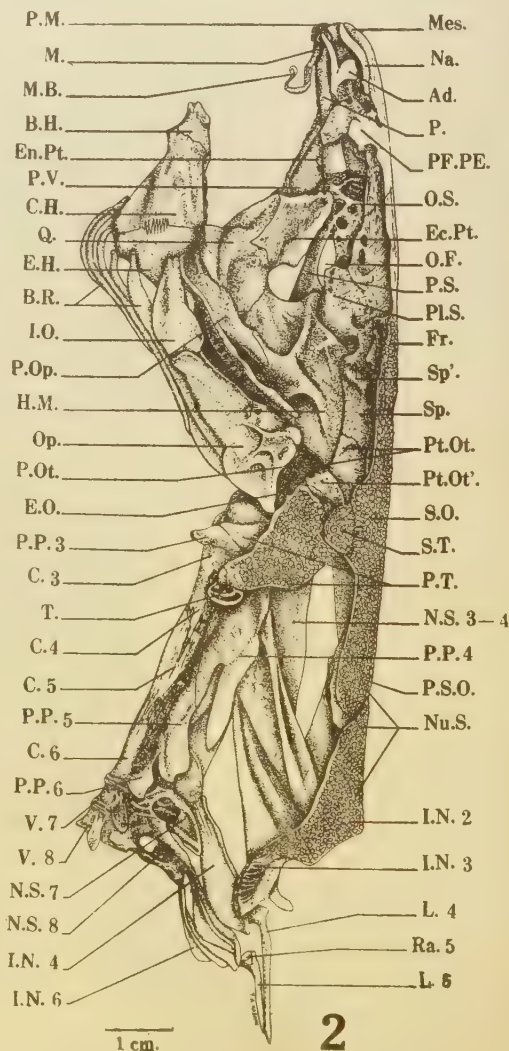


Fig. 2. Lateral view of the skull and related bones.

anteriorly directed prong of the parasphenoid. On the lateral side a considerable portion of the mesethmoid articulates with the composite prefrontal-cum-parethmoid (Fig. 1, *PF. PE.*), and posteriorly its supraethmoid part is suturally joined with the frontals (*Fr.*). The supraethmoid part of the mesethmoid is notched posteriorly to enclose a small portion of the interfrontal fenestra (*I. Fr. Fn.*). The nasals lie in close proximity with the anterior half of the supraethmoid limb. In the ventral view of the skull, the ventral limb of the mesethmoid is seen to be covered over completely by the prevomer.

Nasal. The nasal (Figs. 1 & 2, *Na.*) is a small paired bone lying one on either side of, and almost parallel to, the supraethmoid part of the mesethmoid and thus covering a part of fossa nasalis (Fig. 1, *F.N.*). Each nasal is a thin-walled tubular bone perforated by the anterior part of the supraorbital lateral line canal (Fig. 21, *Sup.L.C.*). In each nasal there are two apertures probably representing the external openings of the lateral line canal system. This bone is pointed at the anterior end but is comparatively broad posteriorly. It has no sutural joint with adjacent bones but is held in position mainly by the connective tissue and to some extent by the continuation of the lateral line canal.

Adnasal. The adnasal (Figs. 1, 2 & 3, *Ad.*) is a paired bone covering the lateral border of the nasal fossa, and lodging the anterior part of the infraorbital lateral line canal (Goodrich, 1909). It is an "axe"-shaped bone the blade of which divides the external nasal opening into anterior and posterior nostrils. The infraorbital lateral line canal is lodged in the 'blade' of the adnasal. The 'handle' of the adnasal is a solid, slightly curved structure touching the premaxilla on the anterior side and palatine (Figs. 1, 2, 3, *P.*) on the posterior and ventral sides. The adnasal, like the nasal, is held in position partly by means of connective tissue and partly by the continuation of lateral line canal.

Prefrontal-cum-Parethmoid. The prefrontal-cum-parethmoid (Figs. 1, 2, 3, 5 & 9, *PF. PE.*) is a paired bone of irregular shape. It is a compound bone formed by the fusion of the prefrontal with parethmoid. A similar condition has been reported by Kindred (1919) and de Beer (1937) in *Amiurus* and by Gregory (1951) in *Ictalurus*. In fact, this appears to be the usual condition in the siluroid fishes. The prefrontal-cum-parethmoid is perforated by a small portion of the supraorbital lateral line canal (Fig. 21, *Sup.L.C.*) and by two branches of the trigeminal nerve. A groove on the ventromesial side of the bone lodges the olfactory bulb and the olfactory tract. Due to the presence of the deep groove for the olfac-

tory bulb, the anterior mesial part of the bone comes to have 2 horizontal wing-like processes or shelves, one dorsal and the other ventral. The dorsal process represents the parethmoid part of the composite bone. The topographical relations of this bone are rather complicated.

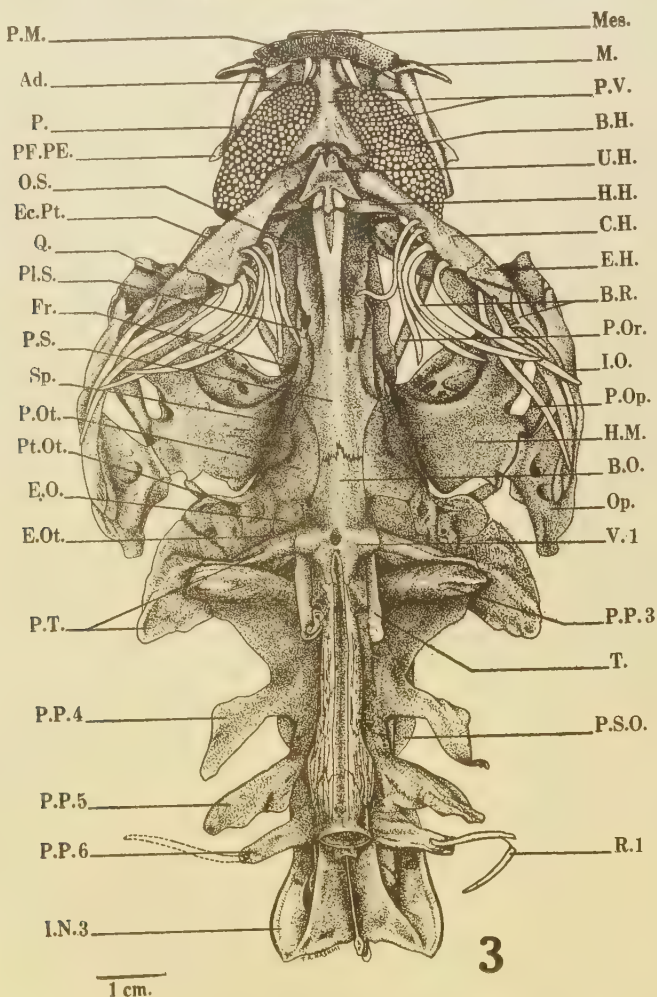


Fig. 3. Ventral view of the skull and related bones.

On the posterior side it meets the frontal above and the orbitosphenoid below. On the inner (mesial) side it articulates with the mesethmoid. Its ventral horizontal process fits over the prevomer while the entire mesial side articulates with the mesethmoid. Ventrally, it meets the

anterior prolongation of the parasphenoid. The composite prefrontal-cum-parethmoid bones of the two sides approach but fail to meet each other in the ventral median line. On the outer side too, it has two short processes which embrace the palatine. On the outer postero-lateral side it shows a fossa in which muscles are attached. On the anterior side it forms the fossa nasalis in combination with the mesethmoid.

Prevomer. The prevomer* (Figs. 2,3,5 & 7, *P.V.*) is paired in origin, but in the post-embryonic stages it fuses with its fellow in the median line to form a single structure (de Beer, 1937). In shape the prevomer resembles a flying bird whose tail is directed towards the posterior end of skull. The wings bear on the ventral side a large number of molariform teeth lodged in shallow sockets, but the median part of the prevomer is smooth on the ventral side. The prevomer articulates dorsally with the prefrontal-cum-parethmoid and also with mesethmoid and endopterygoid. Anteriorly it just touches the mesethmoid but makes no firm connexion with it. Posteriorly it comes very close to ectopterygoid but does not touch it. Its posterior tail-like prolongation in the mid-ventral line articulates with the anterior prolongation of the parasphenoid.

B. THE ORBITO-TEMPORAL REGION

The orbito-temporal region includes the temporal region of the skull and the orbital ring of bones. The temporal region includes two replacing bones, viz., orbitosphenoid and pleurosphenoid, and two investing bones, viz., frontal and parasphenoid. The orbital ring comprises three investing bones, viz., preorbital, suborbital and postorbital.

Frontal. The frontals (Figs. 1, 2, 3, 5, 12 & 21, *Fr.*) form about two-thirds of the roof of the neurocranium. Along the posterior half of their length they are in contact with each other in the median line but in their anterior half they are separated by the interfrontal fenestra (Fig. 1, *I. Fr. Fn.*). Each frontal lodges a part of the supraorbital lateral line canal (Fig. 21, *Sup. L.C.*) and its lateral border represents the dorsal boundary of the orbit. A similar condition has been described by de Beer (1937) in *Salmo*. In the young specimens the frontals are wide apart throughout their length except for a small bridge just in front of the point of bifurcation of the main lateral line canal into supraorbital and infraorbital lateral line canals. The frontal extends anteriorly almost up to the nasal and posteriorly up to the postorbital process of the sphenotic (Fig. 1, *Sp'.*) In young specimens the surface of the frontal is smooth but in older specimens

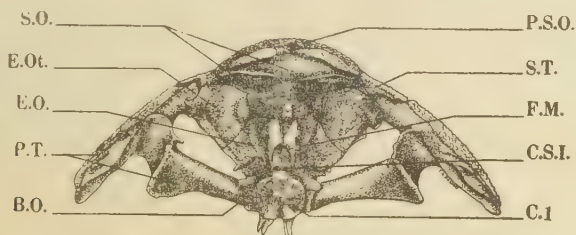
* In older works this bone is referred to as *vomer*. The name prevomer has been adopted to differentiate it from the mammalian vomer with which it is not homologous.

its anterior three-fifth is marked with irregular longitudinal lines, while the remaining part is covered with osseous tubercles or plaques which, according to Gregory (1951), may be regarded as new polyisomers. The protruding ends of the posterior wider region may be termed the post-orbital processes, because the postorbital bones are attached to these processes of the frontal. On the lateral side each frontal, together with the sphenotic forms a deep cup for the attachment of muscles. The frontal is suturally joined on the anterior side with mesethmoid and on the anterior and antero-lateral sides with the prefrontal-cum-parethmoid. Posteriorly it articulates with the supraoccipital above, with the sphenotic along the ventro-lateral margin, and with the pleurosphenoid (alisphenoid) in the region below the sphenotic.

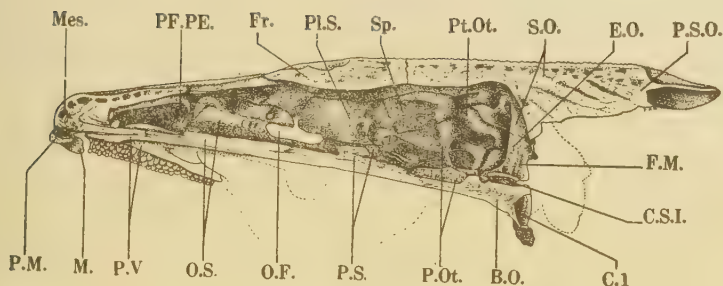
Parasphenoid. The parasphenoid (Figs. 2, 3, 5 & 12, P.S.) is a single sceptre-shaped median bone widening posteriorly to take part in the formation of the cranial cavity. The posterior wider portion is rugged and concave dorsally, whereas the anterior portion is smooth and somewhat convex on the dorsal side. In *Amiurus* the parasphenoid is a compound bone formed by the fusion of the basisphenoid and the parasphenoid (de Beer, 1937), and the same could be the case in *Rita rita* where also the basisphenoid as a separate bone is absent. The parasphenoid forms a small portion of the lateral wall and about one-half of the ventral boundary of the foramina for optic and trigeminal nerves. The bones bounding the parasphenoid are the basioccipital and prootic on the posterior side, the pleurosphenoid (alisphenoid) along the anterior margin, the orbitosphenoid on the posterior lateral side, and the prevomer and mesethmoid on the anterior side. The junction with the mesethmoid in front and the basioccipital behind, is by means of very long needle-like sutural teeth. A posteriorly directed process of the prevomer lies in a distinct longitudinal groove on the ventral side of the parasphenoid.

Orbitosphenoid. The orbitosphenoid (Figs. 2, 3, 5 & 11, O.S.) is paired in origin but later on fuses with its fellow in the midventral line (de Beer, 1937). The disarticulated orbitosphenoid has the shape of an open drain or gutter, open antero-posteriorly but having high side walls extending vertically upwards to meet the frontal and the composite prefrontal-cum-parethmoid. In the midventral line its horizontal portion has a groove lodging the forwardly directed limb of the parasphenoid and the posterior limb of mesethmoid. Its posterior tip has a sutural joint with the pleurosphenoid. Its ventral and outer surfaces are pitted and ridged. The orbitosphenoid comprises the side walls and

floor of the passage of the olfactory tract. Posteriorly, the side walls of this bone enclose the anterior halves of the optic foramen and of a smaller foramen for one of the nerves supplying the eye muscles. Anteriorly there is a crescentic gap between the anterodorsal border of the orbitosphenoid and the prefrontal-cum-parethmoid.



4



5

Fig. 4. Posterior view of the skull. Fig. 5. Sagittal section of the skull.

Pleurospenoid. The pleurospenoid* (Figs. 2, 3, 5 & 13, *Pl.S.*) is a paired bone forming the posterior half of the dorsal boundary of the optic foramen (Figs. 2 & 5, *O.F.*) and the anterior half of the foramen for the trigeminal nerve. It has a distinct groove on its outer surface, in

* The pleurospenoid is known by the name of *alisphenoid* also, but it is not homologous with the mammalian *alisphenoid*.

front of the foramen for the trigeminal nerve. Its posterior border is thicker than the rest of the bone. Its outer surface is greatly pitted for the insertion of muscles. A marked pit near the posterior border denotes the point of contact of the anterior process of the hyomandibular. The pleurospenoid is bounded by frontal on the anterior dorsal side, sphenotic on the posterior dorsal side, prootic on the posterior side, parasphenoid on the posteroventral side and orbitosphenoid on the anteroventral side; all these bones join it suturally. The outer surface of this bone, i.e. the side facing away from the cranial cavity, is slightly concave.

The **parietals** as distinct bones are not represented in the skull of *Rita rita*. In *Amiurus* Allis (1904) has described as parietal a bone which seems to be the epiotic. The corresponding bone in *Rita rita* is, without doubt, the epiotic because it forms the posterodorsal corner and wall of the auditory capsule. The view held by Goodrich (1909) and de Beer (1937), that the parietals have not been lost but have fused with or been replaced by the supraoccipital, is more plausible in the present case.

Preorbital. The preorbital (Figs. 1 & 21, *Pr.Or.*) is the anterior-most link in the chain of orbital bones. It forms the anterior border of the orbit and lodges the infraorbital lateral line canal (Fig. 21, *I.Or.L.C.*). It is attached on the anterior side to the adnasal and on the posterior side to the suborbital. It is a tubular bone and so narrow as just to enclose the infraorbital lateral line canal.

Suborbital. The suborbital (Figs. 1 & 21, *S.Or.*) also is a narrow tubular bone and lodges the infraorbital lateral line canal. In *Amiurus* there are three suborbitals on each side (de Beer, 1937), but there is only one in *Rita rita*. It joins the preorbital anteriorly and the postorbital posteriorly.

Postorbital. The postorbital (Figs. 1, 3 & 21, *P.Or.*) also is a narrow tubular bone and lodges the posterior part of the infraorbital lateral line canal. It is the longest bone of the orbital series. There is only one postorbital on each side unlike *Amiurus* in which there are two (de Beer, 1937). Anteriorly the postorbital joins the suborbital and posteriorly with the postorbital process of the frontal at the point where the supraorbital lateral line canal enters the frontal.

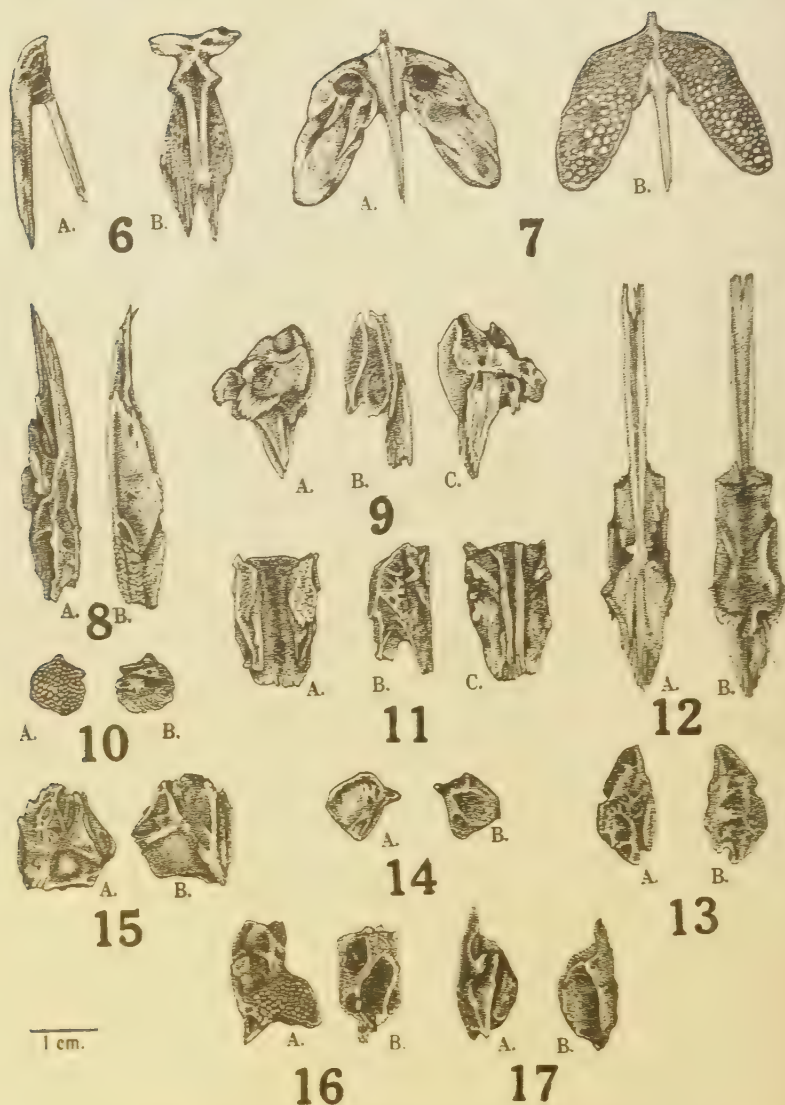
C. THE AUDITORY OR OTIC REGION

Four replacing bones, namely, sphenotic, pterotic, epiotic and

prootic, take part in the formation of the auditory capsule. The opisthotic, which occurs in *Salmo* (de Beer, 1937) and many other bony fishes, is absent in *Rita rita*. Besides the otic bones, the supratemporal, supraoccipital, exoccipital and basioccipital also form a part of the auditory region of the skull. I shall deal with the four otic bones and the supratemporal here and describe the remaining bones in connexion with the occipital region. There is no medial wall of the auditory capsules: the two hemispherical capsules are in open continuation with the cranial cavity. Externally there is no distinct line of demarcation between the auditory capsules and other parts of the neurocranium.

Sphenotic. The sphenotic (Figs. 1, 2, 3, 5 & 17, *Sp.*) forms the anterodorsal side of the auditory capsule. It lodges the postorbital lateral line canal (Fig. 21, *P.Or.L.C.*) which passes along its lateral border and bifurcates into supra- and infraorbital lateral line canals: the former going into frontal and the latter into the postorbital. The sphenotic is an irregular bone and sends out, from its midlateral region, a postorbital process to which stout tendons are attached. On the ventrolateral side it has a groove in which the hyomandibular articulates. The sphenotic in combination with the pterotic forms a deep cleft for the insertion of muscles. The anterior half of the dorsal border of the sphenotic articulates with the frontal while the posterior half of the dorsal border meets the supraoccipital. The posterolateral border of the sphenotic articulates with the pterotic, the posteroventral border with the prootic and the anteroventral border with the pleurosphenoid. On its posteroventral side, the sphenotic shows a deep recess for one of the semicircular canals. A deep concavity on the inner surface constitutes a portion of the auditory capsule.

Pterotic. The pterotic (Figs. 1, 2, 3, 5, 16 & 21, *Pt.Ot.*) is an irregular bone forming the outer portion of the auditory capsule. It is situated behind the sphenotic, and dorsal to the oxoccipital. Its posterolateral border is produced into a prominent post-temporal process whose upper surface is beset with osseous plaques (Figs. 1 & 2, *Pt.Ot'.*) and just in front of which there is a very prominent groove for the attachment of muscles. The groove for the hyomandibular lies on the outer side, below the above-mentioned groove. Its inner surface shows four distinct cavities: one large cavity in the middle, two situated in the ventral wall, and one in the dorsal wall. The large central cavity constitutes a portion of the auditory capsule proper, while the three smaller cavities



FIGS. 6—17. Disarticulated bones of the skull.

6. Mesethmoid: a. lateral view, b. ventral view; 7. Prevomer: a. dorsal view, b. ventral view; 8. Frontal: a. inner view, b. outer view; 9. Prefrontal-cum-parethmoid: a. ventral view, b. inner view, c. dorsal view; 10. Supratemporal: a. dorsal view, b. ventral view; 11. Orbitosphenoid: a. dorsal view, b. lateral view, c. ventral view; 12. Parasphenoid: a. ventral view, b. dorsal view; 13. Pleurosphenoid: a. outer view, b. inner view; 14. Episphenoid: a. outer view, b. inner view; 15. Pterotic: a. outer view, b. inner view; 16. Pterotic: a. dorsal view, b. inner view; 17. Sphenotic: a. lateral view, b. inner view.

lodge the semicircular canals. The pterotic receives a branch of the lateral line canal from the supratemporal and is traversed by postorbital lateral line canal (Fig. 21, *P.Or.L.C.*). On the mesial side the pterotic is bounded by the supraoccipital; on the posterior side by the supratemporal above and the epiotic below; and on the anterior side by the sphenotic above and the prootic below. Between the supratemporal and the epiotic there is adjusted a prong of the posttemporal, touching the pterotic on the posterior side. There is a small foramen on the ventroposterior side for the passage of a nerve; this foramen is rounded in some specimens and oblong in others, and is best seen in the ventral view of the skull.

Epiotic. (*Otosphenoid* of Goodrich, 1909). The epiotic (Figs. 3, 4 & 14, *E.Ot.*) is a relatively small bone occupying the posterodorsal corner of the auditory capsule and attached dorsally to one of the prongs of the posttemporal. A similar condition is met with in *Amiurus*, and de Beer (1937) finds that in that fish the epiotic has taken the place of opisthotic which is otherwise absent. It is possible that in *Rita rita* too, which belongs to the same group, a similar condition prevails. As stated above, the epiotic is attached to one of the prongs of the posttemporal on the dorsal side. Other bones that bound the epiotic are the supraoccipital on the posterior dorsal side, the pterotic on the anterior side and the exoccipital on the ventral side. All these bones join the epiotic by small sutures. The epiotic has no aperture in its walls but its outer surface is ridged. A disarticulated epiotic resembles a hollow pyramid open on the side facing the auditory capsule.

Prootic. The prootic (Figs. 2, 3, 5 & 15, *P.Ot.*) forms the antero-ventral wall of the auditory capsule and is a paired bone meeting its fellow in the mid-ventral line on the dorsal side of the suture between the basioccipital and the parasphenoid. It encloses the foramen for the 7th (?) nerve, which foramen may or may not be confluent with the trigeminal foramen. The prootic is somewhat quadrangular in shape and when disarticulated, shows two pits on the inner side. The posterior pit, which is a part of the auditory capsule, is deeper and circular in outline, while the anterior pit is shallow and irregular. In the thickness of the dorsal wall of the prootic, a large oval tunnel, opening in the posterior pit on one hand and running on to the sphenotic on the other, probably lodges a semicircular canal. The bones bounding the prootic are the sphenotic on the anterior dorsal border, pterotic on the posterior dorsal border, exoccipital on the posterior border, basioccipital and parasphenoid in the midventral line and pleurosphenoid (alisphenoid) on the an-

terior border. The prootic and pleurosphenoid enclose the foramen for the trigeminal nerve between them.

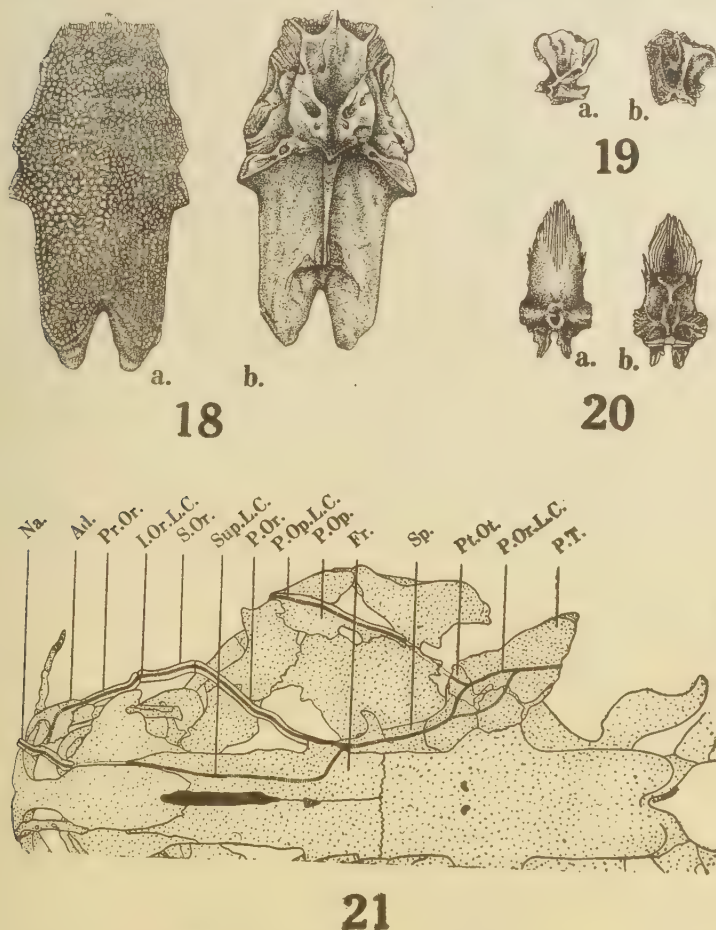
Supratemporal (*Scale bone*). Although the supratemporal (Figs. 1, 2, 4 & 10, S.T.) takes no part in the formation of the auditory capsule, yet it is closely associated with this region and is more conveniently described here. It is a somewhat hexagonal, flattened, scalelike bone and lodges the lateral line canal which afterwards passes into the pterotic. The lateral line canal enters it at the posterolateral corner and leaves it at the anterolateral corner. In the older specimens the dorsal surface of the bone is covered over by bony plaques. The supratemporal meets the supraoccipital on the mesial side, pterotic on the anterior side, and a prong of posttemporal on the ventral side.

D. THE OCCIPITAL REGION

The occipital region comprises the supraoccipital, the two exoccipitals and a basioccipital, all of which are replacing bones.

Supraoccipital. The supraoccipital (Figs. 1, 2, 3, 4, 5 & 18, S.O.) is a median bone which forms the roof of the cranial cavity and is also expanded laterally. Its dorsal surface is convex and covered over with bony plaques. The supraoccipital is an interesting bone in so far as it either replaces, or is completely fused with, the parietals which are absent as distinct bones. A similar condition has been described for *Amiurus* by de Beer (1937), and for the Siluroidea in general by Goodrich (1909). It extends posteriorly much beyond the region of the brain and its posterior half covers about 4 anterior vertebrae, thus aiding in the articulation of the elements of the dorsal fin and its spine. A deep V-shaped notch at the posterior end of the bone permits the first interneural of the dorsal fin to fit in firmly. On the underside of the supraoccipital, there is in the posterior half or so, a distinct longitudinal crest which is very high towards the anterior side but gradually tapers posteriorly. The anterior half of the underside of the disarticulated supraoccipital, is very uneven and beset with ridges and facets for articulation with other bones. An obliquely transverse wall marks the posterior boundary of this region. In front of this wall, on either side, there is a deep pit comprising the dorsomesial part of the cavity of the auditory capsule. This pit lodges a small, flattened, bean-shaped structure with concentric rings, which is probably the otolith of the internal ear. The obliquely transverse wall as well as the mesial wall of that part of the auditory capsule, are perforated by a number of foramina for nerves and blood-vessels. The supraoccipital is bounded

by frontals on the anterior side, by sphenotic on the anterolateral side, by pterotic and supratemporal on the lateral side, and by epiotic on the posterior lateral corner of the auditory capsule. In the posterior view, the supraoccipital is seen attached to the exoccipitals and epiotics. Unlike other bones, the exoccipitals are attached with the supraocci-



FIGS. 18—20 Disarticulated bones of the skull ; FIG. 21. Dorsal view of the skull to show the route of the lateral line canal through bones.

18. Supraoccipital : a. dorsal view, b. ventral view ; 19. Exoccipital : a. outer view, b. inner view ; 20. Basioccipital : a. ventral view, b. dorsal view.

pital by connective tissue only, so that in the dried skull a fissure can be seen between them.

Exoccipital (*Lateral occipital* or *pleuroccipital*). The exoccipital (Figs. 2, 3, 4, 5 & 19, E.O.) is a paired irregular bone which is narrow at the base but somewhat expanded above. It bounds the ventral, ventrolateral and posterior sides of the auditory capsule. A disarticulated exoccipital, looked at from above, appears roughly Z-shaped, with the oblique and the lower horizontal bars enclosing the auditory capsule. The two exoccipitals enclose the foramen magnum completely between them and thus also meet below it, forming the roof of another foramen, the opening of the cavum sinus imparis. The cavum lodges the sinus endolymphaticus. De Beer (1937) has found that in the embryo of *Amiurus*, there is a single foramen which, later on, becomes subdivided horizontally into the passage for the spinal cord and the opening of the cavum sinus imparis. The exoccipital forms a part of the posterior semicircular canal, and is perforated by the foramina for the IX and X cranial nerves. On either side of cavum sinus imparis, and between the exoccipital and basioccipital, there is a cup-like hollow which lodges the sacculus. This hollow can be seen only in a disarticulated exoccipital. The exoccipital is pitted with rounded irregular or elongated markings on all sides. The exoccipital is bounded by the basioccipital on the ventral side, by the supraoccipital on the dorsal side, by the prootic on the anterior side, and by epiotic along the dorsolateral and dorsoposterior borders. The supraoccipital and prootic are joined with the exoccipital by connective tissue only and in a dried skull there is a fissure between them. The rest of the bones are suturally joined to it.

Basioccipital. The basioccipital (Figs. 3, 4, 5 & 20, B.O.) is a compound bone formed by the fusion of the basioccipital proper and the centrum of the first vertebra. A similar condition has also been described in *Amiurus* (de Beer, 1937). Viewed from the ventral side, it is cylindrical with a rounded anterior edge. Posteriorly, it is broader and thicker with a conspicuous concavity on either side for articulation with the prong of the posttemporal bone. The centrum of the first vertebra, which can be distinguished very easily, bears stout sutural forks on its ventral rim for union with the centrum of the second vertebra. On the dorsal side the disarticulated basioccipital has a prominent broad ridge whose dorsal surface is trough-shaped and forms the lower half of the cavum sinus imparis. At the base of the ridge, on either side, there is a shallow groove. In a complete skull this groove forms the basal portion of a tubular cavity in which the sacculus lies. The roof and sides

of this cavity are formed by the exoccipital. The basioccipital is bounded by exoccipital on the dorsal side and by parasphenoid on the anterior side. The part joined suturally with the parasphenoid is covered over dorsally by the prootic. The union of the basioccipital with all the bones including the posttemporal is sutural. On the ventral side, between the basioccipital proper and the centrum of the first vertebra (which is fused with it), there are usually three deep but blind pits, the median one being larger than the two lateral ones. A few minute holes of this type may be present on the sides also.

iii. VISCERAL SKELETON

The visceral skeleton consists of seven arches, the first two of which are modified in the manner characteristic of all Gnathostomata. The first or mandibular arch has two parts, viz., the palato-ptyerygo-quadrata (or simply pterygoquadrata) which leads to the development of the upper jaw, and Meckel's cartilage around which the lower jaw is formed.

The second or hyoid arch serves as the suspensorium by means of which the two jaws are attached to the auditory region of the cranium. The remaining five visceral arches are associated with the gills and are known as the branchial arches.

The bones formed in the region of the gill covers may also be included in the visceral skeleton, though all of them are investing bones.

Two bones, quadrata and palatine*, are formed by ossification in the pterygoquadrata. The investing bones associated with the upper jaw are the premaxilla, maxilla, ectopterygoid and endopterygoid. The posterior part of Meckel's cartilage ossifies to form the articular and prearticular. One large investing bone, the dentary, is associated with the lower jaw.

The hyoid arch consists of the hyomandibular (which effects the suspension of the jaws), and hyoid cornua. The latter comprise the interhyal, epihyal, ceratohyal, hypohyal, and basihyal. All these bones are formed in cartilage. Between the two basihyals, there is a membrane bone, the urohyal. There is no symplectic.

* In some teleosts, e.g. *Salmo fario*, the palatine is of dual origin. It is formed by the fusion of a replacing bone (autopalatine) with a membrane bone (dermopalatine). In *Amia*, only the dermopalatine is present, and in *Cyclopterus* only the autopalatine. In view of the above, nothing can be said with certainty regarding the origin of the palatine in *Rita rita*, unless the development of its skull is studied.

The gill covers are formed of preoperculum, operculum, interoperculum and 8 or 9 branchiostegal rays.

All bones formed in the branchial arches are of the replacing type.

A. UPPER JAW

Quadrate. The quadrate (Figs. 1, 2 & 3, *Q.*) serves for the articulation of the lower jaw and is suturally joined to the hyomandibular on the posterior dorsal side, to the preoperculum on the posterior ventral side and to the ectopterygoid on the anterior dorsal side. Its articular facet for the lower jaw is saddle-shaped and considerably expanded. The anteriorly directed limb of the quadrate, together with the ectopterygoid, provides a concave surface to receive the posterior end of the wing-like process of the prevomer. The anterior limb of the quadrate forms an acute angle with the articulating surface. The quadrate forms the anterior wall and roof of a rectangular space which is bounded by the hyomandibular on the posterior side and the preopercular bone on the posteroventral side.

Palatine. The palatine (Figs. 1, 2 & 3, *P.*) is a long cylindrical bone attached to the base of maxilla anteriorly and to the pterygoquadrate bar posteriorly. It is attached particularly to ectopterygoid by muscles. It is broader at the two extremities than in the middle region and is slightly curved, the concave surface being mesial. In a disarticulated palatine there are two rough spots a little behind the middle, denoting the points where the forked end of the composite prefrontal-cum-parethmoid grasps it. The palatine is toothless.

Premaxilla. The premaxilla (Figs. 2, 3 & 5, *P.M.*) is a paired bone ossifying in association with the pterygoquadrate portion of the mandibular arch. It is quadrangular in outline, and not very thick dorsoventrally. On its ventral side there are numerous villiform teeth lodged in shallow sockets. The teeth come out easily when the bone is boiled in a dilute solution of caustic potash for some time. In the centre of each pit there is a hair-like canal ending blindly. The premaxillae are attached firmly to the mesethmoid dorsally. Beyond the region of its articulation with the mesethmoid, the premaxilla becomes flattened and provides a groove-like facet for articulation with the base of the maxilla and the anterior end of the palatine. The premaxilla is firmly united to its fellow of the opposite side in the median line. A prong of the adnasal articulates with it on the posterodorsal margin but the union is very loose.

Maxilla. The maxilla (Figs. 1, 2, 3 & 5, *M.*) is a very small bone

developed in association with the pterygoquadrate portion of the mandibular arch, and forming the base from which arises the characteristic maxillary barbel or labial cartilage (Jordan, 1905; Goodrich, 1909; Gregory, 1951). The maxilla has a bifurcated base attached to the premaxilla mesially and palatine posteriorly, the connexion with the latter being more firm. In the natural position the maxilla points laterally and is freely movable under the action of two muscles, viz., the *retractor tentaculi* attached a short distance away from the base and the *extensor tentaculi* attached to its base. A similar condition has been described by Edgeworth (1935) in the case of *Silurus glanis*.

Labial cartilage. The labial cartilage (Figs. 1 & 2, *M.B.*) is a long feeler-like structure attached to the distal end of the maxilla and is usually called the maxillary barbel. In a living specimen it is always in motion, up and down and from side to side. Besides this main barbel, there is another pair of barbels, called the mandibular barbels, attached to the undersurface of the lower jaw.

Ectopterygoid. The ectopterygoid (Figs. 1, 2 & 3, *Ec.Pt.*) is a membrane bone very firmly connected with the suspensorial elements in the adult specimen. It is attached to the anterior dorsal side of the quadrate and is best described with the upper jaw. Considering its union with the pterygoquadrate bar, it might have been mistaken for the metapterygoid, but that bone is absent in the Siluridae (Boulenger, 1904). According to de Beer (1937) the metapterygoid ossifies in the posterodorsal portion of the pterygoquadrate cartilage, which would be behind the ectopterygoid. In *Rita rita* there is a gap in the position where metapterygoid should have been, and it is therefore reasonable to regard the bone in question as the ectopterygoid. At the anterior end, on the outer surface of this bone, there is a denticle-like structure with radiating deep lines round it, meant for the attachment of muscles. The anterior margin of the ectopterygoid has a deep rounded indentation to receive the posterior end of the wing of the prevomer. Attached to the posterior margin of the bone there is a fibrous sheath stretching across and forming the roof of the buccal cavity. The ectopterygoid is bounded by the quadrate on the posteroventral side, by the prevomer on the anterior side, and by the endopterygoid on the anteromesial side. The palatine also lies on the anterior side of the ectopterygoid, but at a higher level than the prevomer, and is attached to the ectopterygoid by tendons.

Endopterygoid. The endopterygoid (Figs. 1 & 2, *En.Pt.*) is a small irregularly-shaped, nodule-like bone. A long but thin and narrow lateral prong of this bone is attached by a ligament to the dorsal surface of the

wing of prevomer. The endopterygoid fits between prevomer and orbitosphenoid. Posteriorly it touches the ectopterygoid to which it is also attached by ligament.

B. LOWER JAW

The lower jaw is very sturdily built and is well adapted to the feeding habits of the animal. It is formed in association with Meckel's cartilage which, probably, represents the ceratomandibular part of the mandibular arch (de Beer, 1937). The lower jaw consists of left and right rami which are mirror images of each other. Each ramus consists of 4 elements, namely, dentary, articular, prearticular and Meckel's cartilage.

Dentary. The dentary (Fig. 23 a,b, D.) is the anteriormost bone in each ramus and articulates with its fellow in the median line by a stout ligament. It bears two types of teeth on its dorsal side: villiform teeth attached to the anterior and anterolateral margins, and molariform teeth on the rest of the tooth-bearing surface. The teeth on the dentary, like those on the premaxilla and prevomer, are placed in shallow sockets and they are stouter in the posteromesial region. The dentary covers a part of Meckel's cartilage on the mesial side and is produced posteriorly into a prominent vertical process which may be called the coronoid process. The articular also takes an equal part in the formation of this process. The dentary lodges the mandibular lateral line canal and has six or seven apertures on the ventral and as many as five apertures on the mesial side. If a hair is inserted into the lateral line canal from behind the articular, it comes out through any one of these apertures on the ventral side. The dentary is suturally joined to articular posteriorly and it is a hard task to disarticulate it. A prong of the dentary runs along the ventromesial border of the articular to reach almost its posterior end.

Articular. The articular (Fig. 23 a,b, Ar.) constitutes about 2/5th the total length of the ramus and is as stout as the dentary. It lodges the mandibular part of the lateral line canal which enters it at the posterolateral edge. Its articular facet takes the form of a deep groove. Just below the facet and slightly towards the inner edge, there is a backwardly directed process, which may be called the retroarticular process, as in the case of *Polypterus* (de Beer, 1937). Below the retroarticular process, there is a posteroventrally directed process for the attachment of a stout tendon. This represents the angular process. As mentioned above, the articular also takes part in the formation of the coronoid

process of the lower jaw. On the lateral side, near its suture with the dentary, there is a shallow depression in the articular for the attachment of muscles. The articular is joined suturally to the dentary in front and by a ligament to the quadrate behind. On the mesial side of the articular there is a thick low ridge to the anterior end of which Meckel's cartilage is attached. The prearticular is attached to the mesial side of the articular.

Prearticular. The prearticular (Fig. 23 a, P.A.) is a very small bone attached to the mesial side of the articular, below the coronoid process and posterodorsally to Meckel's cartilage. A bone with a similar position and the same name has been described by de Beer (1937) in *Polypterus*. However, whereas the prearticular of *Polypterus* bears teeth the prearticular of *Rita rita* is very small and without any trace of teeth. Despite this difference, the relations of this bone are very suggestive, and amply justify its being called the prearticular bone rather than a mere ossified denticle on Meckel's cartilage.

Meckel's cartilage. Meckel's cartilage (Fig. 23 a, M.C.) is a rod-like structure placed on the mesial side of the lower jaw in each ramus. It lies in a groove the major part of which is formed in the dentary by an enlargement and inflection of its tooth-bearing part. Posteriorly, the cartilage is attached to the articular. In the dried skeleton Meckel's cartilage shrivels up, but if the lower jaw is boiled in water it swells up and regains its normal size.

C. HYOID ARCH

It can be divided into two main parts, namely, the hyomandibular or pharyngohyal above and the hyoid cornu below. The latter is again divisible into five pieces: interhyal, epihyal, ceratohyal, hypohyal and basihyal. Between the hyoid cornua of the two sides, there is a small, median, membrane bone, the urohyal. The branchiostegal rays, which are eight or nine in number, are attached to epihyal and ceratohyal.

Hyomandibular (Pharyngohyal). The hyomandibular (Figs. 1, 2 & 3, H.M.) is a broad flat bone and is attached by its upper end to the lateral surface of the auditory capsule, forming a suspensorium for the jaws. Its upper border sends out a short conical anterior process which articulates with the pleurosphenoid. On its outer surface the hyomandibular has a triradiate ridge for the attachment of muscles. On its posterior margin there is a curved facet for articulation with the opercular bone. Just above this facet, there is a short, conical, backwardly direc-

ted process. The anterior border of the hyomandibular is not smooth, but shows a broad, rounded triangular process in its middle. At the base of this process there is a small foramen for the passage of the hyomandibular branch of the VII nerve. In some specimens there may be another,

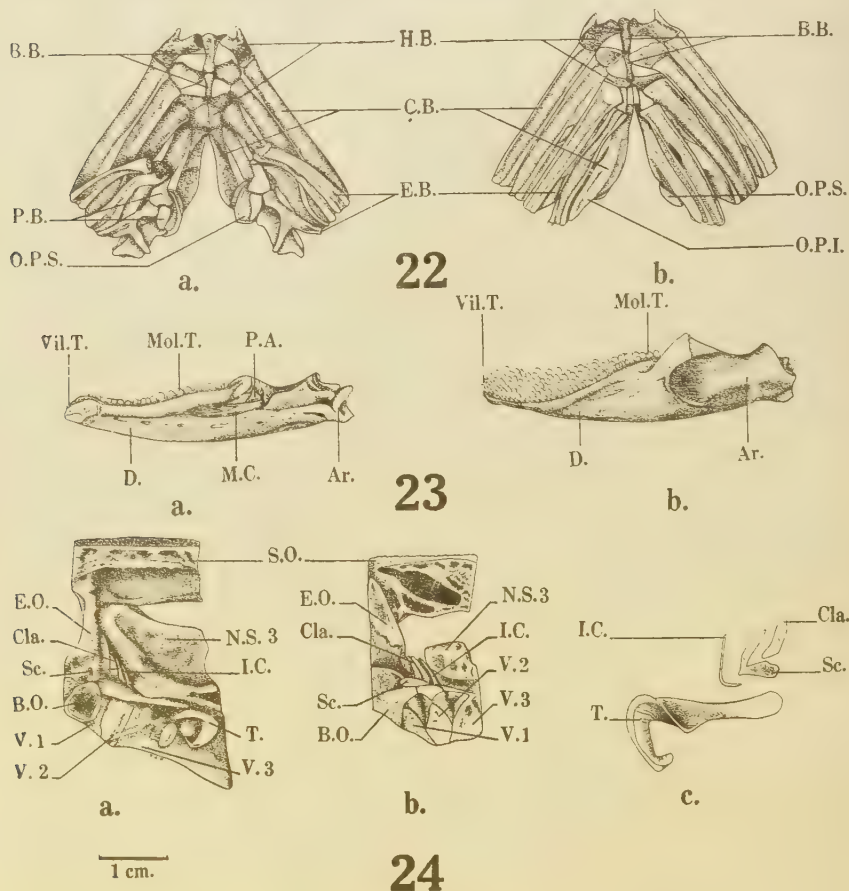


Fig. 22. Branchial arches; Fig. 23. Lower jaw; Fig. 24. Weberian ossicles.

large oval foramen near the upper angle of the triangular process. There is also a squarish foramen at the junction of the hyomandibular and quadrate. On the mesial side, the hyomandibular has two prominent deep grooves for the attachment of muscles. The hyomandibular is sutureally joined to the quadrate on the anteroventral side and to the preoperculum on the posteroventral side. The hyomandibular and preoperculum enclose between them a slipper-shaped foramen for the passage of muscles.

Interhyal. The interhyal is a very small rectangular bone attached ventrally to the posterior end of the epihyal. Its dorsal end is attached by a ligament to the hyomandibular, though in the dry skeleton the two are not in contact.

Epihyal. The epihyal (Figs. 1, 2 & 3, *E.H.*) is a triangular bone attached on the inner (mesial) side of the interopercular. On the anterior side the epihyal becomes very broad and is joined to the ceratohyal by very strong sutures. The epihyal comes very close to the quadrate bone on the dorsomesial border but is not attached to it except by connective tissue. The posteriormost branchiostegal rays are attached to the postero-ventral edge of the epihyal.

Ceratohyal. The ceratohyal (Figs. 1, 2 & 3, *C.H.*) lies on the anterior side of the epihyal, converging anteriorly and mesially to join the hypo- and basihyal. On the posterior side the ceratohyal becomes very broad to join sutureally the wide base of the triangular epihyal. There are six or seven backwardly directed branchiostegal rays attached to the ventromesial border of the ceratohyal. It joins the hypohyal anterodorsally, and the basihyal anteriorly, the union with both the bones being sutureal.

Hypohyal. The hypohyal (Fig. 2, *H.H.*) is a small semilunar bone lying more or less in the median line and attached on the outer side with the basihyal. It encloses an oblong aperture between itself and the basihyal. Its union with ceratohyal and basihyal is sutureal. The hypohyals of the two sides are separated by a V-shaped gap.

Basihyal. The basihyal (Figs. 2 & 3, *B.H.*) is an irregular bone lying at the anterior end of the ceratohyal, and uniting with its fellow of the other side in the median line. Between the two basihyals there is a deep cleft in which the basibranchiostegal or urohyal is lodged. The basihyal is a curved bone: its greater part lies in the same plane as the ceratohyal, but anteriorly it bends dorsomesially to unite with the basihyal of the other side. As mentioned above, it encloses an oblong aperture between itself and the hypohyal.

Urohyal. The urohyal (Fig. 2, *U.H.*) is a median bone placed between the basihyals of the two sides. It has also been called basibranchiostegal, and is, like the branchiostegal rays, a membrane bone. According to de Beer (1937) it is not a part of the hyoid arch but is an ossification between the sternohyoid muscles and is perhaps homologous with the parahyoid of *Polypterus* and of the Amphibia. It has two pairs of posterolaterally directed wing-like processes, one superior pair and

the other inferior pair. The two pairs are united medially by a thin, vertical bony plate which projects slightly posteriorly. The superior process on each side approaches the hypohyal, while the inferior pair touches the mesial side of the basihyal. The anterior end of the urohyal is bifurcated forming left and right halves. Muscles of the so-called tongue are attached to the wings of the urohyal.

Branchiostegal Rays. There are eight or nine branchiostegal rays, two posterior ones attached to the epihyal, the remaining six or seven attached to the ceratohyal. The branchiostegal rays attached to the epihyal are flattened and sabre-shaped, and can readily be distinguished from the rest. These two may be regarded as the subopercular bones which are otherwise absent in the Siluroidea (Goodrich, 1909; Gregory, 1951). All these branchiostegal rays are connected with the opercular bones by means of the branchiostegal membrane and cover the gills.

D. BRANCHIAL ARCHES

There are five branchial arches (Fig. 22 a, b) serving to support the gills. Each branchial arch consists of the right and left visceral bars connected with each other through a median unpaired segment, the basibranchial. Starting from the dorsal side, a typical visceral bar consists of a pharyngobranchial (Fig. 22 a, *P.B.*), a large epibranchial (Fig. 22 a,b, *E.B.*) a still larger ceratobranchial (*C.B.*) and a small hypobranchial (*H.B.*). Except for the hypobranchials of the third, fourth and fifth arches, all segments of the five arches are fully ossified. The first and second branchial arches lack the pharyngobranchial, while the fifth arch is represented only by an unossified hypobranchial and an ossified ceratobranchial. Attached to the ventral side of the pharyngobranchials of the third and fourth arches there is a hemioval membrane bone bearing villiform teeth on its ventral surface. This is the os pharyngeum superius or superior pharyngeal bone. There are only two basibranchial bones. The right and left hypobranchials of the first arch articulate on the anterior end of the anterior basibranchial, while the hypobranchials of the second arch are attached to the posterior end of the anterior basibranchial and anterior end of the posterior basibranchial. The hypobranchials of the third arch are connected to the posterior border of the hypobranchials of the second arch and to the posterior end of the posterior basibranchial. The hypobranchials of the fourth and fifth arches are attached to the posterior border of the hypobranchial of the third arch. The epibranchial of the third arch has a posteriorly directed process arising from its middle and covering a part of the epibranchial of the fourth arch. The ceratobran-

chials of the first four arches are distinctly grooved on the ventral side for the passage of blood vessels. On the side walls of the groove are attached the gill filaments. Epibranchials of the first three arches are grooved along one half of their length. The ceratobranchials of the first four arches are almost straight and of uniform breadth throughout their length but the fifth ceratobranchial is curved to the lateral side subtending an angle of about 105° . This ceratobranchial is covered over by, or has fused with, a membrane bone which bears tooth-like denticles on its dorsal surface and is often referred to as the os pharyngeum inferius (O.P.I.). It bites against the os pharyngeum superius. As regards the last-named bone, there is some controversy about its origin. According to Goodrich (1930) the os pharyngeum superius is formed by the fusion of the pharyngobranchials of the last three arches but de Beer (1937) is of the opinion that the os pharyngeum superius is a distinct bone and has fused secondarily with the third and fourth pharyngobranchials. My observations on *Rita rita* tend to support de Beer's view since some of the pharyngobranchials can be seen separately (i.e. not fused) but attached to the os pharyngeum superius by a ligament.

E. OPERCULAR SERIES OR GILL COVERS

There are three chief bones taking part in this series, viz., opercular, preopercular and interopercular. There are no subopercular bones, which have either become transformed into branchiostegal rays (Goodrich 1909) or have been lost (Jordan, 1905; de Beer, 1937).

Opercular. The opercular (Figs. 1, 2 & 3, Op.) is a paired bone and lies on the posterolateral border of the operculum. It is roughly triangular in shape with its narrow base directed upwards and the acute apex pointing anteroventrally. The base is somewhat concave. The posteroventral side of the operculum is somewhat concave in the anterior half and convex in the posterior half. From the anterior angle of the base starts a low blunt ridge running downwards for a short distance and then flattening out. The posterior tip is connected to the posttemporal by a long ligament. On the anterodorsal side, near the dorsal end, there is a concave facet for articulation with the hyomandibular; and from the middle of this facet, on the mesial side, starts a low blunt ridge which runs to the posterior tip. The opercular is attached to the interopercular on the anterior side and to the hyomandibular on the anterior dorsal side and touches the branchiostegal rays on the mesial side.

Preopercular. The preopercular (Figs. 1, 2, 3 & 21, P.Op.) is an

elongated bone joined suturally to the hyomandibular and quadrate on its anterodorsal side. It encloses a slipper-shaped foramen between itself and the hyomandibular and in this region it is a triangular, bar-like structure. The posterodorsal end of the preoperculum is a little raised laterally from the level of the hyomandibular and it is at this point that it receives the preopercular lateral line canal from the pterotic. It has two distinct apertures on the posterior margin leading to the tunnel of the lateral line canal. The lateral line canal leaves the bone at its anteroventral end. Besides its sutural joint with the hyomandibular, the preopercular articulates with the opercular on the posterior and with interopercular on the anterior sides.

Interopercular. The interopercular (Figs. 1, 2 & 3, *I.O.*) is a small bone broad at the posterior end but tapering towards the anterior end. At the anterior end it articulates with the preopercular above and the epihyal below. Posteriorly it articulates with the opercular. On the mesial side it touches the last branchiostegal ray. The interopercular is slightly curved on its long axis, being convex on the lateral side and concave on the mesial side.

2. VERTEBRAL COLUMN

Two regions can be recognized in the vertebral column of *Rita rita*, viz., the trunk or precaudal region with 10 vertebrae (including the one fused with the basioccipital), and the caudal region with 25 or 26 vertebrae (including the urostyle). Except for the first five, all trunk vertebrae bear distinct ribs, while in the caudal region, ribs occur only on the first three or four vertebrae. All free vertebrae are amphicoelous. In the trunk vertebrae the centrum (Figs. 4 & 5, *Cr*; fig. 25, *C.*) is short and deeply concave. The neural spine is usually directed backwards except in the third vertebra where it is directed forwards. From the base of the neural arch (Fig. 26 b, *N.A.*), on both faces of vertebra, arise paired articulating processes, sometimes called anterior and posterior "neural zygapophyses" (Fig. 28 a, *A.N.Z. P.N.Z.*) respectively. Similar articulating processes, the so-called anterior and posterior "haemal zygapophyses" (Figs. 28 a, 30 a, *A.H.Z. P.H.Z.*) occur on the ventrolateral side of the centrum in some trunk vertebrae. A pair of long processes, called parapophyses, arises from the lateral sides of the vertebrae (Fig. 25 a, b, *P.P.*) and bear ribs. In the anterior vertebrae the parapophyses are lateral in position but gradually bend to the ventral side, and at the end of the trunk region ultimately fuse in the median line to form the haemal arches.

The first six vertebrae are highly modified; the anterior two have no

parapophyses and what are probably the third and fourth vertebrae are fused. The three anterior vertebrae serve to connect the air bladder with the internal ear with the help of a series of small bones, called Weberian ossicles (Fig. 24). These ossicles are 4 in number and are known as (a) claustrum, (b) scaphium, (c) intercalarium, and (d) tripus. There is a great deal of controversy as to the homologies of these ossicles. Because of their close association with the anterior trunk vertebrae, the Weberian ossicles are variously homologized with different parts of the vertebrae. The views of the various authorities are summarized in the following table.

In the case of *Rita rita* the claustrum, scaphium and intercalarium are arranged in a row one behind the other, while the tripus (Figs. 2, 3 & 24, T.) is placed on the lateral side. The scaphium (Fig. 24, Sc.) is attached to the second vertebra at the point where normally the neural arches should have been. The tripus is attached to the third vertebra on the lateral side and may be regarded as the rib of the third vertebra. The claustrum (Fig. 24, Cla.) is attached on the anterior side of the scaphium but has no direct connexion with any vertebra. As it is placed over the posterior margin of the first and the anterior margin of the second vertebra, it is difficult to draw any conclusion from its position. The intercalarium (Fig. 24, I.C.) is a small bone lying behind the scaphium, and is very thin and slender as compared to the other ossicles. The neural canal which is more or less continuous throughout the vertebral column, opens out in the region between the foramen magnum and the third vertebra. The spinal cord in this region is protected on the sides by the claustrum, scaphium and intercalarium, on the ventral side by the second vertebra and on the dorsal side by the anteriorly prolonged neural spine of the third vertebra.

The claustrum is somewhat triangular in shape with one obtuse and two acute angles. The former normally points anteriorly, the more acute angle points upwards, while the less acute angle is wedged between the two limbs of the scaphium. The scaphium is an L-shaped bone the two limbs of which form an acute angle. The horizontal limb is flat spoon-shaped, the concave side of which is directed mesially, enclosing the posterior end of the sinus endolymphaticus. The vertical limb is directed forwards. The point of union of the two limbs of scaphium is wedged into the substance of the centrum of the second vertebra. The intercalarium resembles a hockey stick in shape and is situated behind the scaphium. It is attached to the centrum of the second vertebra by its curved end. The tripus is the largest of the four ossicles and is placed on the side of the third vertebra. Its shape also is more or less like a hockey stick, the

Homologies of the Weberian Ossicles.

Author	Clastrum.	Scaphium.	Intercalarium.	Tripus.
Ramsay Wright (1884)	Spinal process of 1st vertebra	Neural arch of 1st vertebra	Neural arch of 2nd vertebra.	Rib of 3rd vertebra.
	Neural arch of 1st vertebra.	Neural arch of 2nd vertebra	Rib of 2nd vertebra.	Rib of 3rd vertebra.
Sagemehl (1891)	Spinal process of 3rd vertebra.	Neural arch of 3rd vertebra	Neural arch of 4th vertebra.	Rib of 5th vertebra.
	Neural arch of 1st vertebra.	Rib of 1st vertebra.	Neural arch of 2nd vertebra.	Rib of 3rd vertebra.
Nusbaum (1908)	Intercalated arch	Neural arch of 1st vertebra	Neural arch of 2nd vertebra.	Rib of 3rd vertebra.
	Part of neural arch of 1st vertebra	Part of neural arch of 1st vertebra	Neural arch of 2nd vertebra.	Transverse process & rib of 3rd vertebra + rib of 4th vertebra.
Goodrich (1909)	Spinal process of 1st vertebra.	Neural arch of 1st vertebra special rudiment	Neural arch of 2nd vertebra special rudiment.	Rib of 3rd vertebra special rudiment.
Kindred (1919)				
Hora (1922)				
Matveiev (1929)				

blade of which is attached to the anterior wall of the air bladder. The anterior end of the tripus (representing the handle) touches the exoccipital on the side of the cavum sinus imparis and is mesially connected to the spoon-shaped limb of the scaphium by a strong ligament. A short blunt process of the straight limb of the tripus is connected to the third vertebra below the parapophysis and serves as a fulcrum. The blade of the tripus is bound by a strong ligament to a nodule-like process on the centrum below the fulcrum of the tripus.

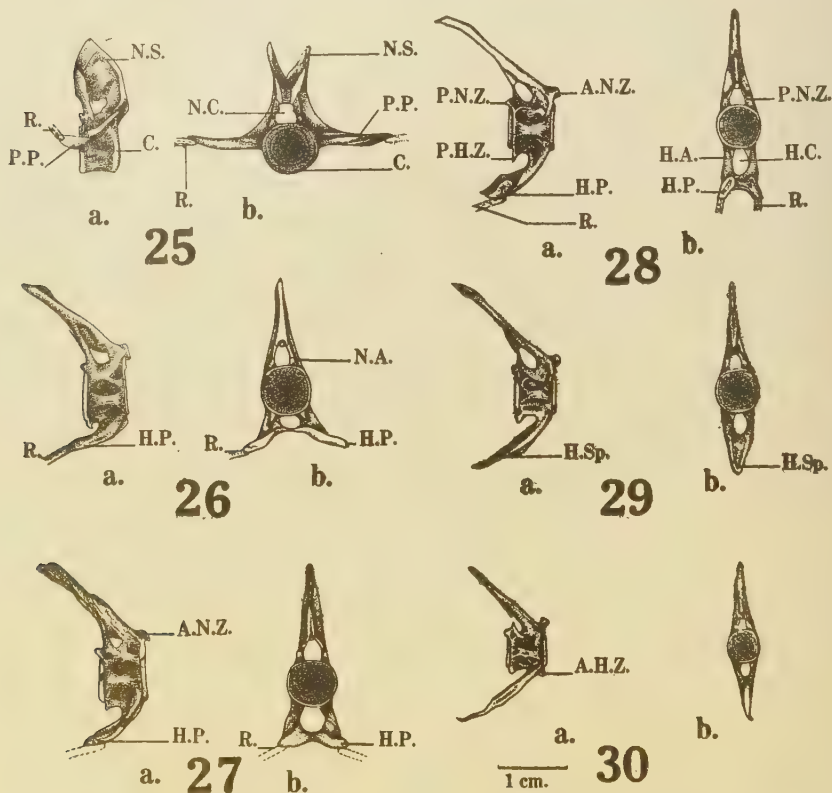
VERTEBRAE OF THE TRUNK REGION : There are 10 precaudal or trunk vertebrae distinguished from the caudal ones by the absence of haemal arches. The centrum of the first vertebra is fused with the basioccipital (de Beer, 1937), the second vertebra is free, and behind it there is a composite structure formed by the fusion of the third and fourth vertebrae. The fifth vertebra is sutureally joined to the posterior side of the fourth vertebra and to its own posterior side is attached the sixth vertebra by comparatively shorter sutures. Behind the sixth there is a row of four free trunk vertebrae held together by ligament.

As mentioned above, the first vertebra is fused with the basioccipital and the dorsal half of its anterior margin is indicated by two cavities on the sides of the cavum sinus imparis, seen after the removal of the exoccipitals. Posteriorly the centrum of the vertebra is deeply concave and shows concentric rings. On the posteroventral margin, the centrum bears a number of downwardly directed processes divisible into right and left groups : these articulating processes fit into corresponding sutures on the anteroventral rim of the second vertebra.

The second vertebra is represented mainly by the centrum and a pair of ossicles (scaphium) occupying the position of the neural arch. The centrum is amphicoelous. On its ventral side the centrum has distinct sutures for articulating with the corresponding sutures of the first vertebra. The posterior sutures of the second vertebra fit into the corresponding sutures of the third vertebra. The posterior edge of the centrum of the second vertebra is grooved on the dorsal side to receive a ridge on the edge of the centrum of the third vertebra.

The third and fourth vertebrae are fused to form a single mass. The tripus is attached on either side of the anterior part of this complex. A little below the tripus, there is a nodule-like process on either side of the vertebra. The complex has two pairs of large lateral processes probably representing the parapophyses of the third and fourth vertebrae. The anterior pair is greatly thickened along its anterior edge and is

sharply curved downwards, presenting a flat surface for articulation with the ventromesially directed prong of the posttemporal bone. The broad base of this process is continued into that of the posterior process. The latter is curved backwards and somewhat downwards. These two pairs of parapophyses touch the anterior and dorsal surfaces of the anterior lobe of the air bladder on either side of the centra. On the dorsal surface



FIGS. 25—30. Vertebrae.

25. Tenth or last trunk vertebra ; 26. Eleventh or first caudal vertebra ; 27. Second caudal vertebra ; 28. Third caudal vertebra ; 29. Fourth caudal vertebra ; 30. Fifth caudal vertebra. In all the figures : a. lateral view, b. posterior view.

of this vertebral complex there is a very high median crest formed by the neural spines of the respective vertebrae. The neural spine of the third vertebra is directed forwards and has bifurcated at the tip to articulate with the supraoccipital on either side of the median crest. The neural spine of the fourth vertebra is very broad especially at the base and is

directed backwards. It bifurcates at the distal end leaving a U-shaped gap. On the posteroventral aspect of this neural spine, there is a deep but narrow groove, which ends ventrally in a deep pit in combination with the bifurcated anterior margin of the neural spine of the fifth vertebra. This pit is in open communication with the neural canal below. Into this groove and pit are fitted the interneurals of the second and third rays of the dorsal fin.

The fourth vertebra has a sutural joint with the fifth, which in turn is joined in the same fashion with the sixth vertebra. The parapophyses of the fifth and sixth vertebrae are very broad, and are directed a little backwards. The sixth vertebra bears the first pair of distinct ribs. They are attached to the ventrolateral margins of the parapophyses. As already mentioned, the four vertebrae behind the second (i. e. vertebrae No. 3-6) are united to form a complex unit. This unit is deeply grooved along the mid-ventral line of their centra. A similar groove is present on the sides below the level of the parapophyses. Through the latter grooves run the blood vessels. The centra of the fifth and sixth vertebrae have small ridges, grooves and pits on the lateral side, both above and below the parapophyses. The neural spine of the fifth vertebra is bifurcated on the anterodorsal side and that of the sixth vertebra on the posterodorsal side. The neural arches of the fifth and sixth vertebrae are perforated from side to side. The neural arch of the seventh vertebra is also perforated in the same way, thus leaving an opening for the spinal nerves. The posterior margin of this opening is formed by the dorsally directed limb of the posterior neural zygapophysis, which in the case of the seventh and a few posterior vertebrae, is in organic continuation with the neural arch. The neural spine of the seventh vertebra is bifurcated, and between its moieties articulates the interneural of the fourth ray of the dorsal fin. Similarly the interneurals of the fifth and sixth fin rays of the dorsal fin articulate between the right and left moieties of eighth and ninth neural spines. The parapophyses of the seventh vertebra are less broad than those of the sixth and are directed outwards and backwards. They bear the second pair of distinct ribs on their ventrolateral margins. The parapophyses of the eighth, ninth and tenth trunk vertebrae are progressively curved downwards and backwards until in the eleventh vertebra they become connected with each other by a horizontal bar to enclose the haemal canal.

VERTEBRAE OF THE CAUDAL REGION : The eleventh vertebra is the first to possess a haemal canal through which run the caudal artery and

vein. It should therefore be regarded as the first caudal vertebra. It must, however, be mentioned that although in structure it resembles the first caudal vertebra of *Labeo rohita* (Sarbah, 1932) and many other teleosts, it lies three or four vertebrae in front of the anus. It bears the sixth pair of distinct ribs on the ventrolateral margins of the parapophysis-like process. The neural spine of the first caudal vertebra is strongly pointed at the distal end and is directed backwards. It is grooved along its entire length. There is one pair of anterior and one pair of posterior neural zygapophyses at the base of the neural arch but only the posterior pair of haemal zygapophyses at the base of haemapophyses. The posterior neural zygapophyses have become separated from the neural arch at their upper ends but are still united with the arches by connective tissue. The centra are deeply pitted on the lateral sides. The edges of the centrum are articulated by ligament with the tenth vertebra on the anterior and the twelfth vertebra on the posterior side.

The second caudal vertebra is like the first except that the bar connecting the two parapophysis-like processes or haemapophyses is broader than in the previous vertebra and the haemapophyses have come closer to each other. The posterior neural zygapophyses have separated a little from the neural arch. The seventh pair of distinct ribs is attached to the posteroventral border of the haemapophyses. In a specimen with 36 vertebrae the haemapophyses of the thirteenth vertebra (i. e. the third caudal vertebra) have almost fused in the middle leaving a small V-shaped gap between their tips. The posterior neural zygapophyses have become completely separated from the neural arch. The eighth pair of ribs is associated with the third caudal vertebra. In some specimens a ninth pair of ribs may also be present. These ribs are directed completely backwards. It is in this region that the anus is situated and the tail, in the usual sense of the word, begins. The fourth caudal vertebra (i.e. the fourteenth vertebra from the anterior end) bears no ribs and its haemapophyses have merged into one another to form the haemal arch and the haemal spine. Anterior and posterior neural zygapophyses and the posterior haemal zygapophyses are distinct and for the first time there is an indication of anterior haemal zygapophyses. The neural spine is slenderer and longer than the haemal spine and is directed very much backwards like the latter. The general plan of the rest of the caudal vertebrae is just the same as described in the case of the fourth caudal vertebra, but with the difference that the anterior haemal zygapophyses become more and more pronounced in the posterior vertebrae. The haemal spines also become slenderer in the posterior vertebrae. The

centrum gradually decreases in size from before backwards. In the thirty-third vertebra, the neural and haemal spines are almost equal in size. In the 36th vertebra the haemal spine is very stout but a distinct neural spine is wanting. There is a spine-like structure fitting into a gap between the neural spine of the thirty-fifth vertebra and the upturned urostyle, but it is difficult to say whether the structure is a neural spine or merely the interneural of the caudal fin ray. However, its position makes the first alternative more probable. The neural and haemal spines of the last 4-6 vertebrae are entangled in the articulation of the fin rays of the caudal fin. The haemal arches attached to the ventral side of the urostyle are very broad and closely connected with one another. In this way a firm vertical plate of bone is formed to the edge of which the caudal fin rays are attached fanwise in a symmetrical manner.

3. RIBS

There are eight or nine pairs of pleural ribs, five pairs attached to the parapophyses of the trunk vertebrae, and the remaining three or four pairs to the haemapophyses of the anterior caudal vertebrae. The first pair of ribs is always attached to the ventral side of the parapophysis of the last complex vertebra (which is the sixth from the anterior end). Ribs in the anterior region of the vertebral column are cylindrical, somewhat compressed, arc-shaped structures, but they are almost straight in the posterior region. In both cases their free ends are directed backwards. A rib is a solid structure, somewhat blunt proximally, but almost pointed at the distal end. All the ribs are embedded in muscles. They are all primary or pleural ribs, there being no ribs of the secondary and tertiary order as present in the cyprinoid fishes (Sarbah, 1932).

4. THE GIRDLES

Both pectoral and pelvic girdles are present and occupy the usual position: the pectoral girdle immediately behind the branchial chamber, and the pelvic girdle in the region of the anus.

(I) PECTORAL GIRDLE

The pectoral girdle (Fig. 31, a, b, c) is situated behind the last gill arch. It is well-ossified and is very stoutly built, but shows a great reduction in the number of elements taking part in its formation. Each half of the girdle is composed of three bones, viz. the cleithrum, the coracoid and the posttemporal. Bones like scapula, mesocoracoid, supracleithrum and postcleithrum, usually present in the pectoral girdle of teleosts, are absent in *Rita rita*. The two halves of the girdle articulate in the midventral line by means of very strong sutures.

Each half of the pectoral girdle consists of a ventral transverse plate and a strong, posteriorly directed, lateral process. The anterior part of the ventral plate is formed by the cleithrum, of which the lateral process (the cubitohumeral process) is a part. The posterior part of the ventral plate is formed by the coracoid. The posttemporal is connected on one hand with the supratemporal of the skull, and on the other with a narrow vertical process at the base of the cubitohumeral process. On the posterior side, at the junction of the cleithrum proper and the cubitohumeral

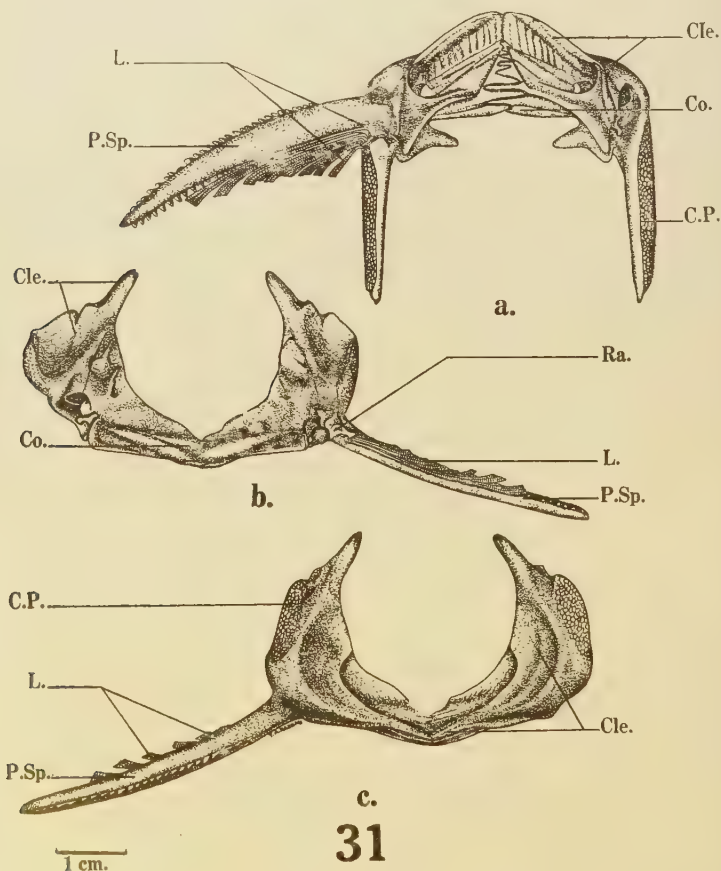


FIG. 31. Pectoral girdle with fin.

a. ventral view ; b. posterior view ; c. anterior view.

process, there is a deep but smooth crescentic groove, the glenoid facet, in which the stout pectoral spine articulates movably. The whole of

the outer surface of the posttemporal and the cubitohumeral process is covered with blunt tubercles (Bhatti, 1938).

Posttemporal. The posttemporal (Figs. 1, 2, 3 & 4, *P. T.*) helps to articulate the pectoral girdle with the skull. Its outer (dorsal) side is covered over with blunt tubercles. Ventrally and mesially it sends a stout prong which articulates with the basioccipital. This prong of the posttemporal grasps firmly the dorsally directed process of the cleithrum. This grip is firm enough to hold the cleithra in position. A dorsomesially directed limb of the posttemporal is wedged between the supratemporal and the epiotic. A little in front of this, the antero-dorsal border of the posttemporal articulates with the corresponding border of the posttemporal process of pterotic (Figs. 1, *Pt. Ot'*; 3). The ventromesially directed limb of the posttemporal is very much expanded in the middle and articulates with an equally expanded parapophysis of the third vertebra. It also helps in grasping the dorsal process of the cleithrum. The posttemporal lodges a part of the lateral line canal, which enters in the middle of the posterior margin and leaves it on the anteromesial border to enter the supratemporal.

Cleithrum. The cleithrum (Fig. 31, *Cle.*) is the largest bone in the girdle and marks the posterior boundary of the branchial chamber. The deep, grooved, semicircular articular surface or glenoid facet for the pectoral spine is situated on the posterior side in the angle between the cubitohumeral process and the mesially directed part of the cleithrum. The latter part of the cleithrum is very deeply concave (like an open drain-pipe) on its posteroventral aspect, and has a shallow groove along its dorsal border. When the coracoid is in position the dorsal groove forms a part of a broad tunnel. The dorsal and the ventral concavities or tunnels lodge the muscles responsible for the movement of the pectoral spine. The ventral tunnel ends blindly on the dorsomesial side of the glenoid facet. The cubitohumeral process of the cleithrum is a very much expanded bony structure which encloses the anterior chamber of the air bladder on the mesial side and is covered with the blunt tubercles on the outer side. Almost at the anterior border of the cubitohumeral process there is a dorsal triangular process which, as mentioned above, fits into a groove in the ventromesially directed limb of the posttemporal. A little posterior to and almost at the base of this process, there is a backwardly directed, short, broad, pointed, process. On the anterior side at the junction of the cleithrum and the cubitohumeral process there is a broad, shallow concavity in which muscles are

attached. The two cleithra are connected in the midventral line by means of a ligament. The coracoid is attached to the cleithrum at three places on its posterior side. There is a long sutural articulation along the posterior dorsal edge of the mesially directed portion of the cleithrum. This edge separates the ventral tunnel-like muscle passage from the dorsal one. The other articulation is over a flat triangular area dorsal to the glenoid facet for the spine. The third region of articulation is rather small and lies on the ventral edge of the ventral muscle passage near the glenoid facet.

Coracoid. The coracoid (Fig. 31, Co.) is very irregular in shape and may roughly be described as having an irregular ventral plate on which stands a strong, oblique ridge. This ridge is low on the mesial side and stands highest on the outer side where its anterior surface has a roughly triangular facet for articulation with the cleithrum dorsal to the glenoid facet. In the midventral line the coracoid articulates with its fellow of the other side by very strong sutures. The anterior edge of the ventral plate articulates with the cleithrum in the region between the dorsal and ventral tunnels. The area of the ventral plate of coracoid anterior to the vertical ridge, forms a partition between dorsal and ventral muscle passages. A broad anteroventrally directed process from the ventral plate articulates with a facet on the ventromesial side of the glenoid facet on the cleithrum. This process, thus, forms a bridge across the ventral muscle passage. In the outer border of the vertical ridge there is a small rounded dent in which moves a process of the pectoral spine. Below the above-mentioned dent, there are two articular surfaces, one convex and almost vertically disposed, and the other concave and oval. The pectoral spine articulates with these surfaces. A prominent club-shaped process just dorsal to the oval articular surface fits into a corresponding concavity on the mesial side of the proximal end of the spine. The vertical ridge is perforated by two foramina, both on the outer side, one at its junction with the ventral plate, and the other a little dorsal to the first. Near the dorsal border of the vertical ridge, on the posterior surface, there is a small, ventrally curved process. It occupies the same position as the mesocoracoid arch in the pectoral girdle of other teleosts. Because of the oblique disposition of the vertical ridge, only a triangular area of the ventral plate can be seen on the posterior side. This process is directed posteriorly and serves for the attachment of muscles of the body wall.

(ii) PELVIC GIRDLE

The pelvic girdle (Fig. 34) consists of two fully ossified oval bony

plates (*Pel.B.*) each produced into two processes anteromesially, and having a long, narrow cartilage attached on the posterior side. The two pelvic bones meet in the midventral line, thus forming the pelvic symphysis. Another point of union is between the inner anteromesial processes of the two sides. The pelvic girdle is situated a little anterior to the anus under the 11th to 15th vertebrae. It has no connexion with the vertebral column and is embedded in the muscles of the ventral body wall. The pelvic bone is concave on the ventral side and convex on the dorsal side. The posterolateral margin of each half of the pelvic girdle is attached to the corresponding pelvic fin.

5. THE FINS

In *Rita rita* there are two paired fins, viz., the pectoral and the pelvic; and three median fins, viz., the anterior dorsal, the anal and the caudal. There is a posterior dorsal or adipose fin also but, as its name shows, it does not contain any fin rays and the greater part of its bulk is composed of fatty tissue. This condition of the adipose fin agrees completely with the general account of fins of the Siluridae (Jordan, 1905). The anterior dorsal fin is armed with a stout defensive spine which is the modified third dermatrich (Goodrich, 1909). Similarly, each pectoral fin is provided with a well-developed defensive spine, in this case formed by the modified first dermatrich. The other fins have no defensive spines.

PAIRED FINS

(i) **Pectoral fin** (Fig. 33). The pectoral fin fits into the pectoral girdle by the very well-developed base of the first dermatrich or pectoral spine (*P.Sp.*). The expanded base of the spine moves in the grooved semicircular articular surface of the glenoid facet, mentioned in the description of the pectoral girdle. There are ten fin rays or dermatrichia in the pectoral fin including the first dermatrich which is modified into the above-mentioned defensive spine. The pectoral spine is sabre-like in appearance and is ornamented with a row of sharp-pointed serrations at its inner and outer borders. These marginal teeth lie in shallow grooves and are triangular in their outline. They point usually towards the free extremity of the spine. The spine has a central cavity filled with connective tissue and fat (Bhatti, 1938). The spine is capable of a good deal of rotary motion in its socket, but its movement is mainly in the horizontal plane. When extended at right angles to the body, the spine cannot be lowered but in other positions it is capable of depression. The remaining nine dermatrichia or lepidotrichia (Fig. 33, *L.*) are connec-

ted with the pectoral girdle by means of three radials. The radial situated near the pectoral spine is comparatively more massive than the other two and fits into a deep pit at the base of the spine. In some specimens two tiny nodules are attached to the first radial. The second radial is expanded

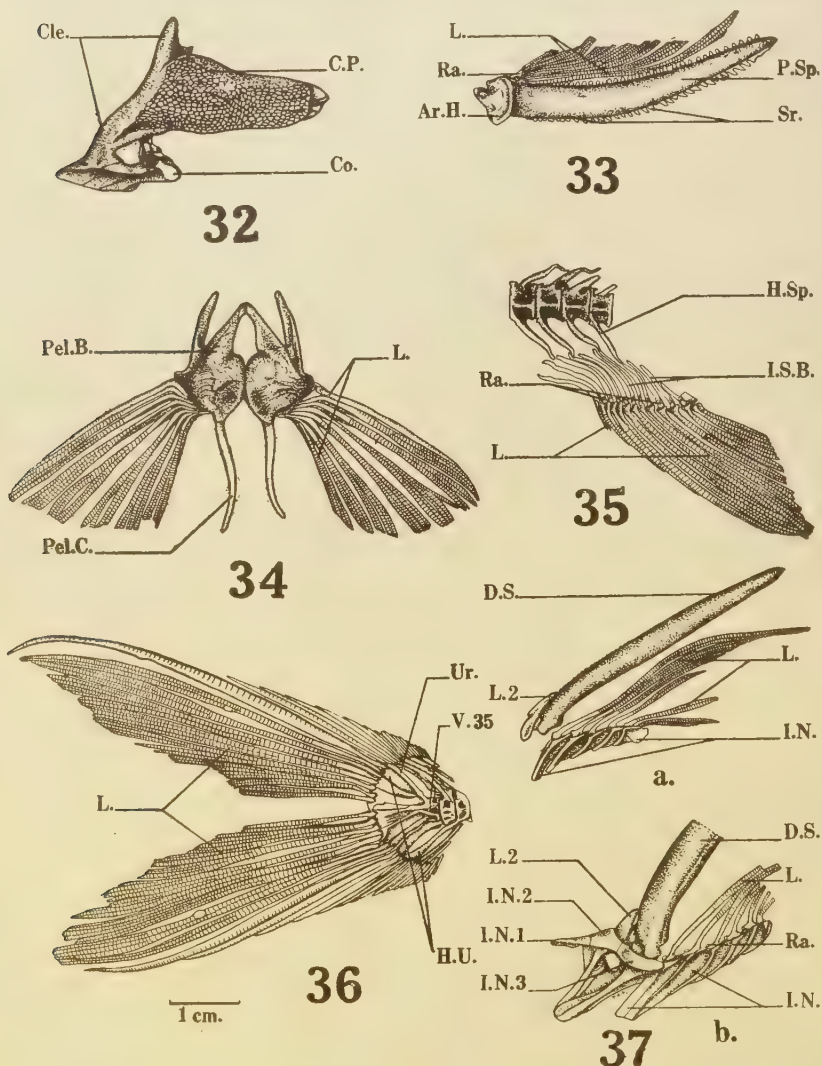


Fig. 32. Lateral view of pectoral girdle; Fig. 33. Pectoral fin; Fig. 34. Pelvic girdle and fin; Fig. 35. Anal fin with related vertebrae; Fig. 36. Caudal fin with related vertebrae; Fig. 37. Anterior dorsal fin: *a.* without the first three interneurals, *b.* with them.

at the proximal end to form a wing-like structure. The third radial is a cylindrical structure with a small curve in the middle. The last two radials are attached to a club-shaped process of the coracoid by muscles. The dermatrichia or lepidotrichia are branched and jointed towards the distal end. The lepidotrich next to the spine is the longest; the other eight gradually decrease in size so that the expanded fin forms more or less a triangle. The lepidotrichia are bifurcated at the proximal end and enclose the distal ends of the radials.

(ii) **Pelvic fin.** The pelvic fins (Fig. 34) are attached to the posterolateral borders of the pelvic girdle. According to Goodrich (1909, 1930) the radials of the pelvic fin of the higher Teleostei seem to have disappeared altogether. The same appears to be the case in *Rita rita* as its pelvic fins are without radials. Lepidotrichia are eight in number and all except the first one bifurcate distally twice or thrice. They are also jointed. At the proximal end also the lepidotrichia bifurcate. The outermost lepidotrich is the largest in size, the remaining lepidotrichia gradually decrease in size towards the mesial side. The fully expanded fin appears like a Japanese fan. The space between the lepidotrichia is filled up in the living specimens by fatty and connective tissues aggregated in the form of big lumps.

MEDIAN FINS

Dorsal fin. The dorsal fin (Fig. 37 a, b) is situated just behind the supraoccipital bone. It can readily be recognized by a very strong spine on its anterior side. The dorsal fin extends over from third to 12th vertebra. The interneurals of the first three rays of the dorsal fin are expanded at their distal end, are covered over with blunt tubercles, and in conjunction with the posteriorly directed part of the supraoccipital form the nuchal shield (Figs. 1 & 2, Nu. S.) extending from the level of the foramen magnum to the base of the dorsal spine (Regan, 1911 ; Bhatti, 1938). The first interneural is a broad plate covered over in the posterior half by blunt tubercles. Its anterior portion fits into and under the bifurcated posterior end of the process of the supraoccipital. The dermatrich corresponding to the first interneural is wanting. The second interneural is a still broader plate with the dorsal side very convex and covered over with bony plaques. It is suturally joined anteriorly with the first interneural and posteriorly with the third interneural but with the latter the junction is only along the posterior lateral margins. The second interneural is also joined with the first in front and the third behind in the median ventral line where they are not flattened dorso-ventrally. In the lower region the triangular spine-like structure formed

by the second and third interneurals fits between the neural spines of the fourth and fifth vertebrae. Behind its plate-like dorsal portion the second interneural is produced into a short triangular, prism-like process which extends dorsally a little beyond the level of the nuchal shield and on which the second lepidotrich moves. There is a pair of obliquely disposed holes on the anterolateral side of the prism-like process, between itself and the nuchal shield. As mentioned above, the second and third interneurals are joined by their lateral ends thus leaving a pair of bigger holes on the posterolateral sides of the process. All the four holes provide for the muscles responsible for the movement of the dorsal spine. In the median line, at the posterior dorsal edge of the third interneural; there is a trigger-like process which fits into a groove on the posterior side of the proximal end of the dorsal spine. The second ray of the dorsal fin resembles an inverted V in shape and lies at the base of the large defensive spine, over the prism-shaped process of the second interneural. The dorsal spine itself is the third dermatrich and rests on a large plate belonging to the third interneural. The spine has 3 prominent heads or condyles at the proximal end, two being lateral and one median. The former articulate on the corresponding facets of the large plate formed by the third interneural, while the median condyle articulates on the posterior side of the triangular prism-like head of the second interneural. The dorsal spine is distinctly grooved in the median line on the posterior side. On the anterior side the spine has a continuous median blunt ridge formed probably by the coalescence of the blunt tubercles as shown by the slightly serrated nature of the edge in some specimens. Blunt tubercles are present on the anterior region of the spine. The spine is sharply pointed at the distal end. It is not a solid structure, but is spongy internally. Behind the spine which represents the third lepidotrich, there are seven branched and jointed lepidotrichia. The tenth lepidotrich is rather small and closely attached to the ninth. The last seven lepidotrichia have a bifurcated proximal end which rests on a nodule-like radial. There are six radials only, because the last two lepidotrichia have one radial between them. The lepidotrichia and radials rest on interneurals. The last three interneurals, that is eighth, ninth and tenth, join to form a single plate. This composite interneural and the one anterior to it do not articulate with the underlying vertebrae; others rest on the bifurcated tip of the neural spines below.

Anal fin. The anal fin (Fig. 35) is situated behind the anus and lies in the region of the 23rd to 26th vertebrae. It consists of fifteen lepidotrichia, 12 nodule-like radials and 11 or 12 interspinous bones. The latter are cylindrical structures directed upwards and slightly forwards.

There are no radials and interspinous bones corresponding to the first two lepidotrichia on the anterior side and the last one on the posterior side. The interspinous bones articulate above with the distal ends of the haemal spine but they do not correspond to or alternate with them. There may be two or more interspinous bones between two haemal pines. The lepidotrichia are bifurcated at the distal ends and are jointed in nature. They are directed downwards and backwards. At the distal end the lepidotrichia are slightly expanded and the anterior border of each lepidotrich lies in a groove formed by the bifurcation of the lepidotrich in front. This overlapping is more pronounced in the case of the lepidotrichia at the anterior and posterior ends. The lepidotrichia of the middle region of the fin are longer than those at the two sides.

Caudal fin (Fig. 36). The posterior end of the vertebral column is modified for the support of the caudal fin. Behind the last centrum, which is apparently normal, there is a rod-like structure, the urostyle (Fig. 36, *Ur.*) which is deflected upwards. The fin rays or lepidotrichia are attached to the urostyle and posterior vertebrae through bony plates or rods called epurals and hypurals. The epurals which are supposed to represent neural spines fused with radials (Goodrich, 1930) are six in number and lie dorsal to the urostyle. The fin rays connected with the last two epurals are very small and are frequently lost when the flesh is removed. Thus in the dry skeleton, only four epurals seem to be involved. The hypurals lie ventral to the urostyle, and are usually eleven in number, though in dry skeletons only nine hypurals may be counted. The hypurals are supposed to represent the haemal spines fused with radials (Goodrich, 1930). The epurals and hypurals together form a firm vertical plate of bone to the edge of which the lepidotrichia of the caudal fin are attached fan-wise in a symmetrical manner. Externally, the fin can be divided into epichordal and hypochordal lobes, symmetrically disposed above and below the longitudinal axis, though the epichordal lobe includes lepidotrichia attached to three hypurals. Being symmetrical externally but asymmetrical internally, the tail fin of *Rita rita* is homocercal. The first (dorsalmost) lepidotrich to articulate with the first hypural is the longest and remains undivided. The hypochordal lobe is composed of about 25 lepidotrichia. The ninth lepidotrich in the hypochordal lobe is the stoutest and usually the longest and remains undivided. Eight lepidotrichia of the epichordal lobe and 9 lepidotrichia of the hypochordal lobe are branched at the distal end and are jointed in nature. The remaining lepidotrichia also show a jointed nature but are not branched at the distal end. Each lepidotrich can be split vertically. The lepidotrichia are

bifurcated at the proximal end and enclose the distal margins of the epurals and hypurals. The space between the bifurcated ends is filled up by muscles and the space between the lepidotrichia by fatty tissue.

IV. CONCLUSIONS AND DISCUSSION

The skeleton of *Rita rita* is built on the typical siluroid plan and has much fewer bones than occur in the primitive bonyfishes like the Cyprinidae. This reduction is due partly to the loss of some bones, and partly to the fusion of certain bones to form complex units. Such a reduction occurs mainly in the skull, but in that case the distribution of the branches of the lateral line canal system affords considerable help in determining the homologies of the various bones. The topography of the bones also provides valuable evidence. The points of special interest in the skull of *Rita rita* are as follows.

In the nasal region of the skull there are two bones connected to the nasal opening. One of these bones is the nasal proper while the other is the adnasal. The adnasal separates the nasal opening into anterior and posterior parts, and is easily identified because it lodges the anterior part of the infraorbital lateral line canal (Goodrich, 1909). The mesethmoid is a compound median bone. Its compound nature was described by Kindred (1919) in *Amiurus* and was confirmed by de Beer (1937). In *Rita rita* also it appears to be a compound bone formed by the same elements as in *Amiurus*, i.e. by supraethmoid and ethmoid. The lateral ethmoid or preethmoid is not an independent bone, but fuses with prefrontal to form a compound bone. In this respect *Rita rita* agrees with *Amiurus* (Kindred, 1919 ; de Beer, 1937), *Ictalurus* (Gregory, 1951) and others. Gregory & Conrad (1938) have recognized the fusion between lateral ethmoid and prefrontal even in *Phago*, *Curimatus*, and *Erythrinus*, which are characins of the subfamilies Distichodontinae, Anostomatinae and Erythrininae respectively. There is no lacrymal in *Rita rita* as also in many other siluroids, e. g. in *Ictalurus* (Gregory, 1951), *Sliurus glanis*, *Auchenoglanis piscutatus*, and *Synodontis schal*, (Goodrich, 1909). There are only three bones in the orbital series, viz., the preorbital, suborbital and postorbital. The postfrontal and the supraorbital, which are usually associated with the orbital region of the skull, are absent. The postorbital, which is normally attached to the pterotic bone (Sarbah, 1932) is attached in *Rita rita* to the sphenotic. As in all cases, the postorbital lodges the infraorbital lateral line canal. The supraorbital has probably fused with the lateral border of the frontal or is, at least, represented by it. Such a possibility has been suggested in *Salmo* by de Beer (1937).

The parietals and postparietals are not represented in *Rita rita* as distinct bones. Allis (1904) had described a parietal in *Amiurus*, but de Beer (1937) thinks that he mistook epiotic for parietal. According to Goodrich (1909) the parietals in siluroids have probably fused with the supraoccipital. Goodrich's view is supported by the following observations on the skull of *Rita rita*.

The frontal extends posteriorly to the level of the postorbital process of the sphenotic. The two frontals are separated from each other in the anterior region by a gap. In the young condition the posterior boundary of the frontal is the same i.e. up to the postorbital process, but the gap extends very far backwards, up to the level of the basioccipital below. This level I regard as the anterior limit of the supraoccipital proper. The region between this level and the posterior limit of the frontal, i. e., the region separated into right and left halves by the gap in the young condition, but unseparated thus in the adult, should be regarded as the region of the parietal, which is originally a paired bone. This region of the parietals is of course fused with the supraoccipital from the very beginning. There is no evidence for the forward growth of the bone to fill in the gap; the latter closes by the approximation of the bony areas on its sides.

It must, however, be emphasized that no judgement can be pronounced on this question merely by studying the osteocranium of an adult fish.

The opisthotic bone, which in *Salmo* takes part in the formation of the auditory capsule, is absent in *Rita rita*. A similar case has been cited by Sarbahi (1932) in *Labeo rohita* and by de Beer (1937) in *Amiurus*. The supraoccipital is produced backwards into a long and broad process which takes part in the formation of the "nuchal shield" (Regan, 1911; Bhatti, 1938). The basioccipital has the first centrum fused with its posterior border (de Beer, 1937). The parasphenoid is a median bone. According to de Beer it is a compound bone as it completely covers the basisphenoid and is probably fused with it. In *Rita rita* it is difficult to say anything about its compound nature, because, except for two deep pits one on either side of the median line, there is no mark to suggest such a fusion. But as there is no separate bone in this region which may be regarded as basisphenoid, it is very probable that the bone under discussion is a compound bone formed by the fusion of the basisphenoid and parasphenoid.

In the suspensorium the symplectic is absent (Goodrich, 1909; Jordan, 1905). The metapterygoid is normally a part of the suspen-

sorial elements, and ossifies in the posterodorsal portion of the pterygoquadrate cartilage (de Beer, 1937), but in *Rita rita* this region of the pterygoquadrate has not ossified and is represented in the dry skeleton by a gap. On the anteromesial side of the quadrate there is a bone which, in view of its union with the suspensorial elements, may be mistaken for the metapterygoid. However as stated above, there is no bone in the region of the pterygoquadrate specified by de Beer. It is, therefore, safer to regard the above-mentioned element as ectopterygoid, a membrane bone which has secondarily become attached to the suspensorial elements.

In the gill covers the suboperculars are absent. Goodrich (1909) is of the opinion that these elements have become transformed into branchiostegal rays, but Jordan (1905) and de Beer (1937) think that these have been lost. In the case of *Rita rita* the last two branchiostegal rays are almost sabre-shaped, being like the others proximally but more flat distally. Normally they are attached to the epihyal in the same fashion as the other branchiostegal rays do. However, in one specimen it was noticed that on the left side the above-mentioned branchiostegals are not attached to the epihyal directly but through the intermediation of a Y-shaped cylindrical bone. This observation may lead one to suspect that the last two branchiostegal rays in *Rita rita* are not exclusively the derivatives of the gulars but are either compound in nature, being formed by the fusion of the normal branchiostegal rays and the suboperculars, or, as suggested by Goodrich, transformed suboperculars.

In the vertebral column, girdles and fins, all the elements are normal, the only difference of opinion being about the nature of the Weberian ossicles. The views of different workers have been mentioned in the full description above, but a few observations prompted by a study of the adult skeleton may not be amiss. As already stated, the claustrum, scaphium and intercalarium of *Rita rita* form the side walls of the passage for the spinal cord. Since in the rest of the vertebral column the passage of the spinal cord is enclosed by the neural arches, these three elements appear to be serially homologous with the neural arches. Of these three, the scaphium is unmistakably wedged into the centrum of the second vertebra and may safely be regarded as the modified neural arch of that vertebra. Most authors, however, prefer to interpret it as a part of the neural arch of the first vertebra. The claustrum and intercalarium are apparently placed over the first and second vertebrae, and may therefore be regarded as the neural arches of the first and second vertebrae respectively. Almost all the authors are in agreement on this point.

The tripus is attached on the side of the third vertebra under the parapophysis. It is, thus, serially homologous with the pleural ribs, and may be regarded as the modified rib of the third vertebra.

V. LIST OF ABBREVIATIONS

<i>Ad.</i>	Adnasal		canal
<i>A.H.Z.</i>	Anterior haemal zygapophysis	<i>I.S.B.</i>	Interspinous bone
		<i>L.</i>	Lepidotrich
<i>A.N.Z.</i>	Anterior neural zygapophysis	<i>L.2,4 & 5</i>	Lepidotrichia No. 2, 4 and 5
<i>Ar.</i>	Articular	<i>M.</i>	Maxilla
<i>Ar.H.</i>	Articulating head	<i>M.B.</i>	Maxillary barbel or labial cartilage
<i>B.B.</i>	Basibranchial		
<i>B.H.</i>	Basihyal	<i>M.C.</i>	Meckel's cartilage
<i>B.O.</i>	Basioccipital	<i>Mes.</i>	Mesethmoid
<i>B.R.</i>	Branchiostegal ray	<i>Mol.T.</i>	Molariform teeth
<i>C.</i>	Centrum	<i>N.A.</i>	Neural arch
<i>C.I., C.3-6</i>	Centra of vertebrae No. 1 and 3-6.	<i>Na.</i>	Nasal
		<i>N.C.</i>	Neural canal
<i>C.B.</i>	Ceratobranchial	<i>N.S.</i>	Neural spine
<i>C.H.</i>	Ceratohyal	<i>N.S.3,4-8</i>	Neural spines No. 3,4-8
<i>Cla.</i>	Clastrum	<i>Nu.S.</i>	Nuchal shield
<i>Cle.</i>	Cleithrum	<i>O.F.</i>	Optic foramen
<i>Co.</i>	Coracoid	<i>Op.</i>	Operculum
<i>C.P.</i>	Cubito humeral process	<i>O.P.I.</i>	Os pharyngeum inferius
<i>C.S.I.</i>	Cavum sinus imparis		
<i>D.</i>	Dentary	<i>O.P.S.</i>	Os pharyngeum superius
<i>D.S.</i>	Dorsal spine	<i>O.S.</i>	Orbitosphenoid
<i>E.B.</i>	Epibranchial	<i>P.</i>	Palatine
<i>Ec Pt.</i>	Ectopterygoid	<i>P.A.</i>	Prearticular
<i>E.H.</i>	Epihyal	<i>P.B.</i>	Pharyngobranchial
<i>En.Pt.</i>	Endopterygoid	<i>Pel.B.</i>	Pelvic bone
<i>E.O.</i>	Exoccipital	<i>Pel.C.</i>	Pelvic cartilage
<i>E.Ot.</i>	Epiotic	<i>PF.PE.</i>	Prefrontal-cum-parethmoid
<i>F.M.</i>	Foramen magnum		
<i>F.N.</i>	Fossa nasalis	<i>P.H.Z.</i>	Posterior haemal zygapophysis
<i>Fr.</i>	Frontal		
<i>H.A.</i>	Haemal arch	<i>Pl.S.</i>	Pleurospenoid
<i>H.B.</i>	Hyobranchial	<i>P.M.</i>	Premaxilla
<i>H.C.</i>	Haemal canal	<i>P.N.Z.</i>	Posterior neural zygapophysis
<i>H.H.</i>	Hypohyal		
<i>H.M.</i>	Hyomandibular	<i>P.Op.</i>	Preoperculum
<i>H.P.</i>	Haemapophysis	<i>P.Op.L.C.</i>	Preopercular lateral line canal
<i>H.Sp.</i>	Haemal spine		
<i>H.U.</i>	Hypurals	<i>P.Or.</i>	Postorbital
<i>I.C.</i>	Intercalarium	<i>P.Or.L.C.</i>	Postorbital lateral line canal
<i>I.Fr.Fn.</i>	Interfrontal fenestra		
<i>I.N.1-6</i>	Interneurals No. 1-6	<i>P.Ot.</i>	Prootic
<i>I.O.</i>	Interoperculum	<i>P.P.</i>	Parapophysis
<i>I.Or.L.C.</i>	Infraorbital lateral line		

P.P.3-8	Parapophyses No. 3-8	Sc.	Scaphium
Pr.Or.	Preorbital	S.O.	Supraoccipital
P.S.	Parasphenoid	S.Or.	Suborbital
P.S.O.	Posterior process of supraoccipital	Sp.	Sphenotic
		Sp'.	Postorbital process of sphenotic
P.Sp.	Pectoral spine		
P.T.	Posttemporal	Sr.	Serrations
Pt.Ot.	Pterotic	S.T.	Supratemporal
Pt.Ot'.	Posttemporal process of pterotic	Sup.L.C.	Supraorbital lateral line canal
P.V.	Prevomer	T.	Tripus
Q.	Quadrate	U.H.	Urohyal
R.	Rib	Ur.	Urostyle
Rr.	First free rib	V.,V.1-3	
Ra.	Radial	V.7,8,35	Vertebrae
Ra.5	Fifth radial	Vil.T.	Villiform teeth.

VI. REFERENCES

- Allis, E. P., 1904. The laterosensory canals and related bones in fishes. *Int. Mon. Anat. Physiol.*, **21** : 401.
- de Beer, G.R., 1937. *The development of the vertebrate skull*. Oxford.
- Bhatti, H.K., 1938. The integument and dermal skeleton of Siluroidea. *Trans. zool. Soc. Lond.*, **24** : 1-102.
- Boulenger, G.A., 1904. *Cambridge Natural History*, VII. *Teleostei (systematic part)*. London.
- Edgeworth, F.H., 1935. *The cranial muscles of Vertebrates*. Cambridge.
- Goodrich, E.S., 1909. *A Treatise on Zoology*, edited by E. Ray Lankester. Part IX. *Vertebrata Craniata (Cyclostomes and Fishes)*. London.
- 1930. *Studies on the structure and development of vertebrates*. London.
- Gregory, W. K., 1904. The relations of the anterior visceral arches to the chondrocranium. *Biol. Bull.*, **7** : 55-66.
- 1951. *Evolution Emerging : a survey of changing patterns from primeval life to man*. New York.
- Gregory, W.K. & Conrad, G. M., 1938. The phylogeny of Characin fishes. *Zoologica*, New York, **23** : 319-360.
- Hora, S.L., 1922. The homology of the Weberian Ossicles. *J. Asiat. Soc. Bengal, Calcutta*, **18** : 1-4.
- Jordan, D.S., 1905. *A guide to the study of fishes*, Vol. II. New York.
- Kindred, J. E., 1919. The skull of *Amiurus*. *Ill. Biol. Mon.* **5** : 1-120.
- Matveiev, B., 1929. Die Entwicklung der vorderen Wirbel und des Weberschen Apparates bei Cyprinidae. *Zool. Jahrb. Jena (Anat.)*, **51** : 463-534.

- Nusbaum, J., 1908. Entwicklungsgeschichte und morphologische Beurteilung der Occipitalregion des Schädels und der Weberschen Knöchelchen bei den Knochenfischen (*Cyprinus carpio* L.). Anat. Anz. Jena, **32** : 513-532.
- Regan, C.T., 1911. The classification of the Teleostean Fishes of the Order Ostariophysi, 2. Siluroidea. Ann. Mag. Nat. Hist. Lond., ser. 8, **8** : 553-577.
- Sagemehl, M., 1891. Beiträge zur vergleichenden Anatomie der Fische, iv. Das Cranium der Cyprinoiden. Morph. Jahrb., **17** : 489-595.
- Sarbahi, D.S., 1932. The endoskeleton of *Labeo rohita* (Ham. Buch.). J. Proc. Asiat. Soc. Bengal (N.S.), **28** (1) : 295-347.
-

ANNOUNCEMENT

L. H. Newman, Esq., The Butterfly Farm, Salisbury Road, Bexley, Kent, England, wishes to contact a professional Pakistani entomologist who would like to do business with Europe by sending choice butterflies alive, preferably in the chrysalis stage.

Bruelia elegans sp. nov., a new louse parasitic on
the Australian crow, *Gymnohorina tibicen*,
with a supplementary note on the genus *Bruelia* Keler
(Mallophaga : Ischnocera)

MUHAMMAD ATIQU'R RAHMAN ANSARI

M. Sc., Ph. D. (Panjab), D. Sc. (Paris), F. R. E. S.

Institute of Hygiene and Preventive Medicine, Lahore.

INTRODUCTION

The genus *Bruelia* Keler 1936 was based on *B. brachythorax* (Giebel 1874) (= *B. rossittensis* Keler 1936), a louse occurring on the Waxwing *Bombycilla garrulus garrulus* (Linne) : Bombycillidae. Since then several species, formerly included in the genus *Degeeriella* Neumann 1906 (= *Nirmus* Nitzsch 1818) have been transferred to this genus with the result that now it is composed of 125 species, out of which 36 are described from corvine hosts.

The British Museum (Natural History) at London received eight specimens of *Bruelia* collected by R. Mykytowycz from the crow *Gymnohorina tibicen* shot in Canberra (Australia). These specimens were forwarded to me for comparison with other species described from crows, ravens and rooks. They were found to belong to a new species described below.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr (Miss) Theresa Clay for the loan of specimens. My thanks are also due to Miss Athar, Miss Tasneem and Mr Saleem for making the drawings.

Bruelia elegans sp. nov.

(Text-figs. 1—25)

TYPE-HOST :—The Australian Crow, *Gymnohorina tibicen*.

This species is distinguished from other species of the genus occurring on Corvidae in the male genital armature and female vulvar chaetotaxy.

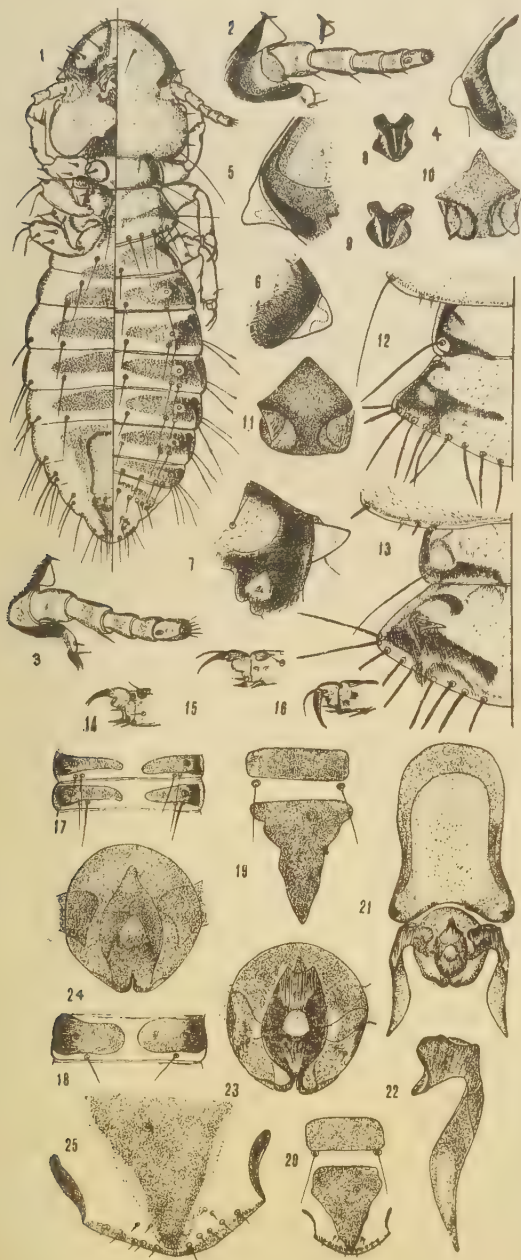
MALE (Holotype)

1.548 x 0.502 mm., fairly well built with conspicuous and heavily sclerotised dorsal plates.

Head 0.397 x 0.389 mm., cephalic index 1 : 0.979. Preantennal region 0.163 x 0.321 mm. (index 1 : 1.969), marginal carina well developed, depressed centrally with small hyaline margin, ventral counterpart narrow, interrupted medianly and then continuous with the premarginal carina. Preantennal chaetotaxy as shown by Clay (1951). Antennae showing very slight sexual dimorphism, basal segment 0.055 mm. long, more robust than other

***Bruelia elegans* sp. nov.**

(1) Dorsal and ventral aspects of male, (2) Male antenna, (3) Female antenna, (4) Dorsal aspect of male conus, (5) Ventral aspect of male conus, (6) Dorsal aspect of female conus, (7) Ventral aspect of female conus, (8) Pharyngeal sclerite of male, (9) Pharyngeal sclerite of female, (10) Gular plate of male, (11) Gular plate of female, (12) Male thorax, (13) Female thorax, (14) Fore-leg tarsus of male, (15) Meso-leg tarsus of male, (16) Meta-leg tarsus of male, (17) Male tergal plates V-VI, (18) Female tergal plate V, (19) Male VII sternite and subgenital plate, (20) Female VII sternite and subgenital plates, (21) Male genital armature, (22) Paramere, (23-24) Two different aspects of mesosomal plate, (25) Female genital plate showing vulvar chaetotaxy



segments, segments II - V 0.055 mm., 0.036 mm., 0.036 mm. and 0.32 mm. respectively. Conus exhibits sexual dimorphism as shown in text-figs. 4-7. Male conus shorter and blunt while in female this structure is longer and pointed. Post-antennal region 0.211 x 0.389 mm. (index 1 : 1.843), temples rounded, marginal temporal carina narrow, the number and arrangement of setae as in other species of *Bruelia* described from corvine hosts (Ansari, 1956c). Gular plate as shown in the text-figs. 10-11, exhibits considerable sexual dimorphism (text-figs. 8-11). Pharyngeal sclerite in male squat and narrow (text-figs. 8-9).

Prothorax 0.092 x 0.238 mm., transverse, with a long dorsal hair in the postero-lateral angle. Pterothorax 0.158 x 0.405 mm., posterior margin rounded, slightly diverging laterally, posterior margin with 8-9 dorsal and a small, often spine-like, ventral seta on each side. Legs concolorous with the body, outer margins well sclerotised, terminal parts of the three legs as shown in the text-figs. 14-16.

Abdomen 0.901 x 0.502 mm., elliptical, with broadly rounded last composite segment, widest at segment V or VI. Segments II-VIII with well developed tergal plates (text-fig. 17), approximated and varying considerably in form, area and pigmentation in various specimens, the pattern, however, is invariable, IX tergite triangular and considerably narrow. Sternal plates II-VI well developed, transverse, narrow and confined in the middle. Subgenital plate as shown in the figure (text-fig. 19). Chaetotaxy as shown in the figure and table below. The setae are definite in number and position except some minute setae on the terminal segments which generally vary from species to species.

Genital armature 0.298 mm. long, well developed, almost constant in all the specimens examined. Basal plate 0.178 x 0.103 mm., rounded anteriorly, laterally well sclerotised. Mesosomal plate more or less rounded, 0.079 x 0.063 mm., simple with well developed central portion, does not resemble any of the mesosomal plates so far encountered in corvine *Bruelia*. Parameres 0.126 mm. long, widest in the middle, proximal head strongly developed, with a transverse socket to accommodate the rounded condyle of the basal plate, anterior lateral margin modified to move freely along the mesosomal plate.

FEMALE (Allotype) more or less resembles the male, the important differences are, however, shown in the text figures 3,6,7,9,11,13,18,20 and 25. The dorsal abdominal setae scarce, of the pattern seen in *Bruelia*

glandarii (Denny) and allied forms (Ansari, 1956a), given in the table below.

ABDOMINAL CHAETOTAXY OF MALE AND FEMALE *Bruelia elegans* SP. NOV.

Holotype (Male)				Allotype (Female)		
Tergal		Sternal	Pleural	Tergal	Sternal	Pleural
Pterothorax	8-9+8-9	1+1	1+1	7—8+7—8	1+1	1+1
Abdominal segment						
II	—1+1—	1+1	—	0—1+1—0	1+1	—
III	1+1+1+1	1+1	—	0—1+1—0	1+1	—
IV	2+1+1+2	1+1	2+2	1+1+1+1	1+1	1+1
V	2+1+1+2	1+1	2+2	1—2+1+1+1	1+1	2+2
VI	2+1+1+2	1+1	3+3	1+1+1+1	1+1	3+3
VII	2+1+1+2	—	3+3	1+1+1+1	—	3+3
VIII	3+1+1+3	—	4+4	1+1+1+1+1+1	—	3 V—
IX	6—7+7—6	—	2 Vent	1+1+1+1+1+1+.....	—	2 V+1
X—XI	3+3	6+6 marginal		Vulva—Chaetotaxy scarce	(text-fig. 25)	

NOTE ON CHAETOTAXY : In male the VIII tergite is with two subequal post spiracular, one posterior and one tergocentral seta on each side. IX with one long lateral, one short and a long post-spiracular and four short setae on each side. X-XI with three short tergo-central setae on both sides arranged obliquely so as to form an inverted 'V' with the component row of setae on the other side. Other setae long, of subequal length. In female the VIII tergite is with one long lateral, one long post spiracular

MEASUREMENTS (IN MILLIMETERS) OF *Bruelia elegans* SP. NOV.

IN CANADA BALSAM.

Holotype (male)		Allotype (female)	Paratypes (males 3)	Paratypes (females 3)
Head : total	0.397x0.389	0.444x0.444	0.401-0.406x0.389-0.412	0.444-0.467x0.444-0.464
pre-antennal	0.163x0.321	0.203x0.373	0.163-0.168x0.325-0.341	0.191-0.193x0.361-0.369
post antennal	0.211x0.389	0.226x0.444	0.126-0.234x0.389-0.412	0.203-0.230x0.444-0.454
Prothorax	0.092x0.238	0.111x0.269	0.084-0.095x0.242-0.244	0.092-0.098x0.262-0.266
Pterothorax	0.158x0.405	0.174x0.405	0.146-0.168x0.353-0.401	0.168-0.178x0.393-0.400
Abdomen	0.901x0.502	1.242x0.548	0.891-0.941x0.502-0.541	1.187-1.242x0.535-0.540
Head index	1:0.979	1:1.000	1:0.905—1.014	1:1.000—1.049
L:B, preantennal	1:1.969	1:1.856	1:1.996—2.017	1:1.891—1.232
L:B, postantennal	1:1.843	1:1.965	1:1.766—1.849	1:1.765—2.187
Antennal segments :				
I—	0.064	0.064	Genital armature : total : 289—0.309+0.103—0.127 B.P. : 168—0.194+0.071—0.092 M.P. : 079—0.092 P.M. : 111—0.126	
II—	0.055	0.055		
III—	0.040	0.040		
IV—	0.032	0.032		
V—	0.032	0.032		

and one tergo-central seta. IX with one short and a long lateral seta, followed by two short and a long seta arranged on posterior margin of the united tergal plate and a long tergo-central on both sides. On the ventrum there are two long antero-lateral, three short (one above the other) and one long and a short postero-lateral seta. Vulvar plate with two setae in the superior row and five spinous setae in the posterior row. Other setae do not call for any special remarks.

MATERIAL EXAMINED : Holotype (male), Allotype (female) from *Gymnohorina tibicen* from Canberra, Australia in R. Mykytowycz collection, 19. VI. 1956. Paratypes (two males and two females, 19. VI. 1956 and one male and a female ACT. VII. 1956) from *Gymnohorina tibicen* (other data as given above).

REMARKS : The form of the head of this species resembles *Bruelia multipunctata* (Clay). The dorsal abdominal chaetotaxy is as seen in *Bruelia glandarii* (Denny). It differs from all the species of *Bruelia* so far described from the corvine hosts in the male genital armature and the female vulvar chaetotaxy.

A Supplementary Note on the Genus *Bruelia* Keler 1936.

The genus *Bruelia* Keler 1936, has aroused great interest in recent years on account of wide distribution amongst distantly related groups of birds, viz., Coraciiformes, Piciformes, Trogoniformes and Passeriformes. The passers, however, form the major hosts. A perusal of the host-list (Hopkins & Clay, 1951) will show that a very meagre proportion of passerine birds have so far been examined and consequently it is not possible to draw any conclusive inference from our present scanty knowledge of bruelias occurring on perching birds.

The genus *Bruelia* does not form a clear cut and homogeneous group. It is composed of a large number of puzzling similar species and it is not surprising that old authors based several species on females alone (which are very much alike in very closely related species) and thus failed in many cases to establish the correct specification. So many interesting features appeared during the consideration of the systematics of these lice that a general review of the whole series is worth while although it might involve some repetition.

Through the kindness of the trustees of the British Museum (Natural History), London, I have been able to examine 37 species from Corvidae,

17 from Turdidae and 18 from Timallidae. Five species from the New World were, however, loaned to me by Mr M.A. Carriker Jr. All the species show various degrees of morphological similarity and are obviously related and derived from a common ancestral stock. Some of the important features of the species occurring on corvine hosts are given below.

The *Bruelia* species infesting crows and ravens fall within the range of 1.423-2.111 mm. in length and none of the species is separable on the basis of size. The presence or absence of characteristic colour pattern (marginal carinae on the preantennal region of head, cephalic dorsal plate, temporal carina preantennal, preocular and postocular nodus, gular plate, thoracic and abdominal plates, viz., paratergal, tergal pleural and sternal plates) is often a very useful guide to the identity of species.

The shape of the head and characters of the carinae have been found very useful features throughout the genus. Proportional length and width of the head, preantennal region and hind head have been found considerably variable in different groups of species. According to the characters of the cephalic carinae these species fall into the following clear-cut categories.

- 1 (8) Marginal carina entire.
- 2 (5) Marginal carina runs along the entire outer rim of the preantennal region, uniformly sclerotised throughout.
- 3 (4) Anterior plate simple.
- 4 (3) Anterior plate wanting. [ex *B. biguttata* (Kellogg et Paine), *B. b. docilis* Ansari, *B. koslovae* (Clay)].
- 5 (2) Marginal carina feebly sclerotised in the middle. (ex *B. argula* (Burmeister), *B. leucocephalus* (Nitzsch) Ansari, *B. quadrangularis* (Rudow), *B. afzali* Ansari].
- 6 (7) Marginal carina although feeble in the middle, yet also borders the entire rim of the preantennal region. [ex *B. multipunctata* (Clay), *B. uncinosa* (Burmeister), *B. u. plena* Ansari, *B. nawabi* Ansari].
- 7 (6) Marginal carina not only feebly sclerotised in the middle but also hanging posteriorly at this point. [ex *B. tasnimae* Ansari, *B. t. variegatus* Ansari, *B. saleemi* Ansari, *B. atharae* Ansari, *B. cryptoleucus* Ansari; *B. perweenae* Ansari].

- 8 (1) Marginal carina distinctly interrupted at one or two points.
- 9 (12) Marginal carina interrupted or indented in the middle only.
ex *B. biocellata* (Piaget).
- 10 (11) Margin at the interrupted point hyaline.
- 11 (10) Margin at the interrupted point furnished with a triangular pigmented area. [ex *B. deficiencia* (Piaget), *B. zavattariornis* Ansari, *B. zohrae* Ansari]
- 12 (9) Marginal carina interrupted both medianly and laterally.
- 13 (14) Lateral interruption incomplete, anterior plate distinct, merging posteriorly with the dorsal tegument.
- 14 (13) Lateral interruption complete, anterior plate well separated from the dorsal cephalic integument. [ex *B. glandarii* (Denny), *B.g. perscoreus* Ansari, *B. clayae* Ansari, *B. nitzschi* Keler, *B. hopkinsi* Ansari, *B. meinertzhageni* Ansari, *B. husaini* Ansari].

More recently Eichler (1944-*Cervinirmus* for *B. uncinus* N.), Conci (1941-*Meropsiella* for *B. apiastri* Denny), Ansari (1947- *Painjunirmus* for *B. pengya* Ansari and *Traihoriella* for *B. punjabensis* Ansari), and Eichler (1949-*Guimaraesiella* for *B. rotundifrontalis* Eichler and *Xobugirado* for *B. menuraelyrae* Conde) have suggested the introduction of generic names for some of these groups. If such names are acceptable, it is well to remember that each group is connected with the other by intermediate forms (Clay, 1951). On this account, I would rather prefer to retain for these assemblages the vague term Group, since the term genus implies a compact group, distinctly limited and separated by some closely recognisable features from other related species.

In a few instances the antennal characters, particularly the length and robustness of basal segments, are of value (ex *B. husaini* Ansari, *B. biguttata* Kellogg et Paine). The size and shape of the conus, number of facets and size of the individual facet in eyes seem to vary from species to species. Unfortunately these features are not easy to be estimated and therefore cannot be readily appreciated. I have considered these characters unreliable for the time being.

The form of the prothorax and pterothorax as a whole is the most important reliable external feature by which some of the species may be

recognised. In some species the prothorax is usually with a distinct dorsal posterior pigmented area, while in others this area is rudimentary or is not well demonstrated. The apparent shape, however, depends upon the sides, which may be straight or projecting. The posterior margin of the pterothorax is either strongly angulate or broadly rounded on the abdominal segment II. Pterothoracic dorsal setae vary considerably from one group to another.

The form of the abdomen is more or less constant throughout the genus. Excluding obvious teneral forms and considering only adults, the tergal sclerites range from those in which these plates are irregular, triangular pieces confined to the sides through those with very faint areas to those in which the tergal plates show no signs of pigmentation and hardness (ex *B. glandarii* Denny, *B. zohrae* Ansari, *B. multipunctata* Clay and *B. elegans* Ansari). Variation of tergal chaetotaxy is considerable. A primary separation of species into various groups based upon the abdominal chaetotaxy is a feature of great importance and convenience. In some there are only tergo-central and post-spiracular setae, while in others there is a continuous row of setae (ex *B. nitzschi* Keler, *B. zohrae* Ansari, *B. biocellata* Piaget). Sternal plates do not exhibit any important specific distinction. In some the sternal plates are narrow, transverse rectangles while in others wide, squat blocks.

Most authors who have studied the genus would emphasize the high degree of variability found in most allied forms. My work is based entirely upon external morphological features but I cannot deny the fact that in many species the only completely reliable characters are those provided by the male genitalia. This organ serves only one function, is located internally and is probably less affected as compared to other morphological features by environmental conditions. The male genital armature is also less subject to adaptive changes during phylogenetic history. A comparative study of these may, therefore, help to trace the interrelation of the group more clearly than the external characters on which the current classification is mostly based.

Specific differentiation based upon male genitalia, of course, would lead at times to problems of nomenclature, as it may be difficult or even impossible to determine the specific identity of forms described before the importance of the male genitalia was even realized. Some of the earlier eminent workers did not only ignore the real value of male genitalia

as a check to specific determination but also did not pay any serious and special attention to males with the result that they frequently did not hesitate in establishing species on female specimens. Even very carefully written descriptions in such cases have been found to lend no guidance to species. As I have pointed out in earlier papers (Ansari, 1955;1956a-d), the female in the genus *Bruelia* are helpful only as far as the grouping of allied species is concerned. In some cases, either through loss of original specimens, failures to make a sufficiently accurate description by the authors, descriptions based on females or for some other reasons, I have not found it possible to satisfy myself about the application of a name and such names are introduced as unidentified species (*Nomina dubis*).

In this connection it is well to point out that specific features are little developed in the female genitalia. The differences which may sometimes be found in the vulvar chaetotaxy and subgenital plate are of subspecific value alone. Although under the International rules of Zoological Nomenclature, a specification of a FEMALE HOLOTYPE is perfectly admissible, it might prove impossible to determine the specific identity of such a specimen and the description therefore would be valueless for taxonomic purposes. In the case of the genus *Bruelia*, at least, the workers will earn a gratitude of future systematists if they always base their species on MALE HOLOTYPE alone. An elaborate note on sexual differences, based on a typical FEMALE HOLOTYPE will, however, be a supplementary attribution to a confident specific identity, and should be invariably added to all the descriptions of species, wherever possible.

As I have pointed out above, the females in *Bruelia* serve a useful purpose in grouping allied forms. Allotypes, therefore, serve a necessary evil. A recent move to discard this designation (de Mellon & Zumpt, 1951 and 1953) will probably prove detrimental to the systematic studies of Phthiropteran parasites in general and *Bruelia* species in particular (Ansari, 1956a-d).

REFERENCES

- Ansari, M. Atiqur Rahman, 1947. Mallophaga (Ischnocera) infesting birds in the Punjab (India). Proc. Nat. Inst. Sci. India Calcutta, **13** (6) : 253-303.
- 1955. Studies on Ischnoceran Mallophaga parasitic on Turdidae. Pak. Jour. Hlth. Lahore, **5** (2) : 47-76.
- 1956a. Studies on *Bruelia* species (Mallophaga) occurring on true thrushes. Biologia, Lahore, **2** (1) : 102-143.

- 1956b. A brief survey of *Bruelia* species (Ischnocera : Mallophaga) parasitic on the babblers and laughing thrushes (Timaliidae). Pak. Jour Hlth. Lahore, **6** (3) : 133-154.
- 1956c. A revision of *Bruelia* (Mallophaga) species infesting the Corvidae, Part I. Bull. Brit. Mus. (Nat. Hist.). London, **4** (8) : 371-406.
- 1956d. A note on Allotype as applied to Mallophaga. Pak. Jour. Hlth. Lahore, **6** (4) : 190.
- 1957. A revision of *Bruelia* (Mallophaga) species infesting the Corvidae. Part II. Bull. Brit. Mus. (Nat. Hist.). London. (in press).
- Clay, T., 1951. An introduction to the classification of Avian Ischnocera (Mallophaga), Part I. Trans. Roy. Ent. Soc. London, **102** (2) : 171-195.
- Conci, C., 1941. Due nuovi generi e tre nuove specie di Mallophagi dei Meropes. Boll. Soc. Ent. Ital., **73** (7) : 99-107.
- de Mellon, B. & Zumpt, F., 1951. Restrictions of types. Jour. Ent. Soc. Africa, **14** : 150.
- Eichler, W., 1944. (Rev. Appl. Ent., B. 1944). Stettin. Ent. Ztg., **105** : 80.
- 1949. (Rev. Appl. Ent., B. 1949). Boll. Soc. Ent. Ital; **79** : 11.
- Hopkins, G. H. E. & Clay, T., 1951. A check list of the genera and species of Mallophaga. Brit. Mus. (Nat. Hist.) London.
- Keler, S., 1936. Ueber einige Mallophagen aus rositten. Arb. Morph. Tax. Ent. Berlin-Dahlem, **3** : 256-364.
- Zumpt, F., 1953. Why worship types. Rev. Ecuat. Ent. Parasit. Ecuador, **1** (3) : 87-89.

SUGGESTIONS TO CONTRIBUTORS

Papers for publication in the *Biologia* should be typed in double spacing. They should include a short abstract and conclude with a summary of the contents. Tables (except very small ones), figures and legends should be on separate sheets of paper and their approximate position marked in the text. Footnotes and tables should be avoided as far as possible. Nothing in the text, except scientific names, should be underlined.

References should be cited in the text by giving the author's name followed by the year of publication in brackets. At the end of the paper they should be listed in the alphabetical order of the name of the authors in the following style:

Ahmad, M., 1950. 'The phylogeny of termite genera based on imago-worker mandibles. *Bull. Amer. Mus. Nat. Hist.*, 95: 37-86.

Illustrations should be made in line drawing preferably on heavy Bristol board. If the number of blocks is too large, or if coloured or half-tone blocks are included, the author may be required to bear the entire cost of such blocks. The size of the plate after reduction should not exceed 7 x 4½ inches. The reduction desired should be indicated on the illustration.

A copy of the galley proofs is usually sent to the author for correction. Authors should not insert new matter into proofs or correct faults in the style or arrangement of their papers at this stage.

Authors will receive 25 reprints free of charge; extra copies will be supplied at cost price.

All correspondence should be addressed to the Chief Editor, The Biological Laboratories, Government College, Lahore.

Other publications of The Biological Society of Pakistan

Monograph I. Fungi of West Pakistan by Sultan Ahmad.

This is a list of 1219 species of Fungi collected by the author from West Pakistan. About 1,000 of these are new records for this area. The Monograph is provided with a complete host-index and a large map of West Pakistan and adjoining areas. 126 pp., cloth bound, size 9½" x 7". Price Rs. 10/- only.

Monograph II. The Codling Moth, *Cydia pomonella* (Linn.) in Baluchistan by Nazeer Ahmad Janjua, M. Maqsood Nasir and Ghulam Ullah Khan Choudhry.

The codling moth is a serious pest of apples, pears and quinces all over the world, and is firmly established in the former province of Baluchistan. The authors have subjected this pest to intensive investigation for 7 years (1941-1947) and have amassed a wealth of information regarding its distribution, food plants, nature and extent of damage, life and seasonal history, and the natural enemies. The Monograph contains 90 tables, 36 graphs and one coloured plate. Indispensable for Economic Entomologists. Price approx. Rs. 10/-.

Monograph III. Grasses of West Pakistan by Sultan Ahmad and R. R. Stewart.

A complete illustrated account of all the hitherto known grasses of West Pakistan with keys to the genera and species. (Ready early 1958).